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FIELD SYSTEM

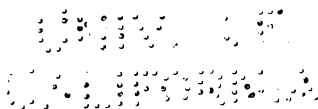
BY

FRANK B. GILBRETH

M. AM. SOC. M. E.

GENERAL CONTRACTOR

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BY

FRANK B. GILBRETH

THE
GILBRETH
METHOD

THE GILBRETH "FIELD SYSTEM."*

How a Successful Contractor Has Solved the Accounting Problem—Loose Leaf Memoranda Take the Place of Cash Book, Journal and Ledger—High-Priced Bookkeepers Are Unnecessary.

BY JOHN P. SLACK.

Organization in the contracting field presents two phases which often seem to greatly diverge. One, the possibilities in theory, and the other, the possibilities in practice. It is in the application of theory, in its reduction to an ultimate working basis, that proof lies. The proof of the pudding lies in the eating no less truly than the proof of theory in the result of its application. The factor which varies, and which often brings apparently logical theories to an unfortunate conclusion, is the difference between working conditions which obtain in actuality, and ideal conditions which unfortunately exist only in theory.

*This article, which appeared in "The Business World" for November, 1907, should be read by every owner of this book, because it clearly outlines the dependence of Gilbreth's office system upon his "Field System." It shows how the loose-leaf reports from the field are made to serve the place of an elaborate set of books, and how it becomes unnecessary to employ high-priced bookkeepers.

The direction of a large body of men of various degrees of intelligence, working in different localities, some perhaps far removed from headquarters, is a proposition requiring experience, brains, and a highly specialized training in the art of handling men. The large contractor executing many contracts simultaneously has this proposition to face, and the problems which must be solved are many and puzzling.

The manufacturer as a rule groups his tools, human and mechanical, at one location, possibly under one roof, in any case in one plant. His forces, under effective direction, may work as a unit; one branch of the industry is within sound of the whirl of machinery incident to the next step in the process of manufacture. Such contact makes for unity, and system may more nearly follow the points of least resistance. A contractor has no such grouping of his forces by location to aid him. One structure is erected in one state and another perhaps a thousand miles distant. The one building may be a factory, the other a city sky-scraper. Both are structures, but further than this the analogy may cease. Such conditions, peculiar as they are to the industry, must be met by a completeness of organization, and by an effectiveness and comprehensiveness of systematization, which will make for results in the strenuous competition which obtains in the building trade.

A notable instance of the application of a working system through which field work may be executed from beginning to end is found in the organization of

Frank B. Gilbreth of New York. His "Field System" has become almost a by-word in the building trades, since its completeness and effectiveness have been excelled by no contractor's working system which has yet been devised. It is by no means the work of one man, or any few men. Many of the suggestions contained therein have emanated from the lips of the humblest workmen, and none of its effectiveness is lost through the fact that such suggestions are expressed in the terse, significant language of the workmen themselves.

For several years previous to its recent publication the Gilbreth "Field System" was open to the inspection only of the men in the employ of that organization. Only a limited number of copies of the volume were in existence, each being numbered, and the possessor of each being accountable for its return even to the extent of being bonded in a small sum to cover its loss. Notwithstanding such precautions, unscrupulous competitors sought in many ways to obtain the information contained in this volume. Office boys were bribed, certain pages were photographed, and discharged superintendents in one or two instances carried the book with them. However, its publication makes such attempts no longer necessary, and shows a most broad-minded and generous spirit on the part of the contractor as well.

A feature of the Gilbreth "Field System" which is worthy of comment, is the system of accounting without books, which it outlines and which has been

in practical use by this organization for some little time. The idea is sufficiently broad in scope to make it adaptable to other than the needs of contractors alone, and is so economical that a number of owners of buildings erected by Frank B. Gilbreth, have adopted it for use in their factories as well. As an illustration of its effectiveness in large contracts, there may be cited three complete industrial towns which the Gilbreth organization erected, each in the phenomenal time of a few months; one at Sprague's Falls, Maine, one at Piercefield, N. Y., and another at Canton, N. C. On each of these contracts the system of accounting without books, fully described below, was used, and the size of the contracts alone furnishes eloquent testimony to the excellence of the system. It has been the execution of such contracts as the three above noted which has associated with the Gilbreth name the phrase of "towns to order" and which amply justifies its use.

The Gilbreth system of accounting has been utilized under all kinds of local conditions in nearly all the states, and in the provinces of Canada as well. It provides for no cash book, journal nor ledger, but in their place substitutes what is in fact a systematic set of memoranda. Their completeness is such that the owner may see at a glance each Saturday what the total cost of a given structure has been up to the previous Thursday. The system shows furthermore, what the cost of materials will be for the completion of the job, namely, the materials required in addition to the

check bills as compared with the initial estimate on the cost of the undertaking.

The method of procedure is as follows:

When the organization is awarded a contract, an estimate of the total cost is compiled and itemized in detail. Cost of labor and cost of the materials for each item that enters into the estimate are separated. When this has been done, a copy of the estimate book is given to the owner for his information as well. When materials are to be purchased, the regular form of order (see O 10382, page 65) is given to the man furnishing the materials and a duplicate of this order is sent to the clerk on the job, and by him is placed on a Shannon File alphabetically, under the name of the firm furnishing the materials. On their receipt, the job clerk gives the person furnishing such materials a ticket for each portion of the shipment (see P 543, page 68), retaining a duplicate copy of the partial receipt on a Shannon File.

When goods are shipped, the firm furnishing the materials is required to forward duplicate bills to the job. These bills are immediately filed alphabetically on a Shannon File. The clerk permanently attaches the order O 10382 (page 65) to the file, and thus checks and approves "prices correct," and the terms and conditions of the order. The bill does not receive its final checking until he has attached as well a "final shipment" form such as P 543 (page 68), or the stub of O 10382, to the bill. After the clerk has attached to the bill the "order" which checks the price, terms

and conditions, the "final shipment" receipt which proves the goods received on the job with quantities and cost correct, it is then checked and approved by the timekeeper (see bill stamp). The bill is then numbered beginning with one, and as the bills are checked the latest number is placed on the top of the file and then bound with McGill fasteners. These bills, in packages of one to fifty, correspond to the journal pages in an ordinary set of books, and are permanently filed numerically, whereas on the index file they were placed alphabetically under the name of the man furnishing the goods. All bills of the job are then either on index file where they can readily be found alphabetically, or else they are permanently located on the check bill file numerically, and may be referred to only by their number.

It is desirable, for many reasons other than that of checking up actual cost of the work as compared with the estimate, to have labor and material separated in the accounts. Consequently, the "M" sheet has been devised (see M 15702, page 62), on which bills for material are listed. It will be seen that one line is sufficient for any one bill, and that the name of the party furnishing the materials may be placed under the "Remarks" column. The bill number column serves as the posted column of a ledger, while material sheet number will be seen on the bill stamp on the next to the last line.

After bills have been listed on the "M" sheet, they are filed away for reference only in case of dispute,

since the "M" sheet will give all the information required to the owner or the representative of the contractor who is responsible for the cost of the job not exceeding the estimate.

As quickly as these "M" sheets have been filled out, they are listed on a cost report (see CR 126, page 72). This cost report simply deals with the "M" sheet number, its date and its total. The system for labor accounting is still more simple than the method of recording the cost of material. The time book is made in triplicate, one copy of which is forwarded to the owner each week, one copy retained in the book on the job, and one copy forwarded to the main office of the contractor.

The problem of eliminating the cost of entering footings from the time book into an ordinary ledger and then handling in accordance with the usual methods, is met as follows:

The time book (TB) sheet (page 59) is filed according to date, the most recent on top, and is secured with McGill fasteners. These time sheets are then entered in the first column of the cost report sheet (CR, page 72), merely by writing in the TB sheet the number, the date and the amount. It will be seen that the total of column number one in the cost report sheet (page 72) is then the total cost of the labor to date. Added to the total of column number two in the cost report (the total cost of materials which has been actually checked as to quantities, prices and extensions), the cost of all checked and approved

items to date, is given. Thus far, the cost report does not differ in great degree from the usual form of book-keeping as found in every well-conducted contractor's office. It is, however, incomplete in that it does not contain full particulars for the information of the owner as to the real cost and liability of the contract to date. Therefore, columns numbers three, four and five have been added to this cost report sheet for the following data:

Column three is the same as column two, except that it contains the record of materials bought and delivered to the office direct instead of to the job. This column is seldom used, but occasionally it becomes necessary.

Column four is for such items as, for instance, the balance of \$2,000 on a \$5,000 plumbing contract, \$3,000 of which, as payment on account, has been approved and entered on the "M" sheets as included in column two.

Column five is to include the full complement of "orders." Copies of these are sent by the purchasing department of the contractor's main office to the job for items such as interior marble work, etc., the materials for which have been purchased, and the work on which is being executed in some shop or quarry, perhaps many miles from the site of the building. At the same time, such an item eventually becomes a liability, and consequently, each week, the time-keeper goes through his Shannon File of "O's" (see page 65) or orders, and sees that each and every one not yet attached to a bill is listed in column five,

taking care to include all items of the previous week's cost report, minus those attached to checked bills during the week following. The cost report thus compiled becomes useful to a great many people who are interested in the contract. The superintendent is constantly reminded how the labor item is running on his contract as compared with what is expected of him on the cost of labor.

Columns numbers one, two and three of the cost report (page 72) show the total cost of check items to date, and so far as the actual bookkeeping is concerned, the accounting department uses only these first three columns. The superintendent, contractor and owner are able to see at a glance how the fractional cost of the contract to date is comparing with the estimate made and given by the contractor to the owner. The item of unfinished labor is the only indefinite one, and variation from that source is narrowed down more and more closely each week.

"O's" (page 65) or orders show the actual price for which materials will be delivered. They also show the comparison with the contractor's original estimate. It is customary with the Gilbreth organization to have the owner approve each "O" before the contract is awarded, thus enabling the owner to see exactly what expenditure will be made for materials, as compared with figures in estimate book, before such materials are actually purchased. Therefore, the only item left in question is the eventual total of column one, viz., the labor column.

In summarizing this system as a unit, and the functions for which it has been devised, it will be seen that the check bill file becomes the journal. Listing of bills on the "M" sheet (page 62) is the same as a ledger made up of footings of columns, while the clerk who simply follows out the directions written in the blank spaces on these manifold books, has, perhaps unconsciously, become a bookkeeper. This phase of the system has proved especially advantageous, since few bookkeepers are good outside men, and outside men are almost never good bookkeepers. Furthermore, it comes within the comprehension of the practical superintendent of the job, who has probably worked his way up from apprentice boy or a technical graduate, and has never had real training in the principles of practical bookkeeping.

The Gilbreth system of accounting without books accomplishes, then, six things:

1. It does away with experienced or high-priced bookkeepers.
2. It shows the cost of the job each Saturday up to the previous Thursday night.
3. It shows the owner the cost of the materials before they are bought.
4. It shows constantly the comparative cost of the work with the contractor's estimate book.
5. It is a system of bookkeeping without books. It files the original memorandum and saves cost of copying and errors of copying.
6. It saves the cost of expert bookkeeping.

GENERAL OUTLINES OF FIELD SYSTEM

This system contains the written ideas of the most successful men in our employ.

In printing it we have in view the following aims:

1. *TO HAVE THE BEST PRACTICE* in all departments put in writing for the benefit of all employees.

2. *TO AVOID REPEATING ORALLY*, by putting in writing, all those instructions from which 'here are no exceptions.

3. *TO MAINTAIN THE POLICY OF THIS FIRM*, namely—that the best work will in the long run bring us the most profit, success and satisfaction.

Maintaining this system has contributed to our success. It has enabled us to make a specialty of "speed work," because our superintendents, foremen and timekeepers are trained on the "duplicate part" system.

As our organization is built thus, like a machine, we can supply additional foremen, who, being already trained to their duties, know what is expected of them and can take charge of the work immediately at any point.

Nothing in this system hinders progress. Improvements will be incorporated as approved. These rules in their present condition have been proved good by the great increase in our business during their use.

All employees must follow these rules to the letter unless they receive written permission to suspend certain rules.

Employees who fail to abide by the spirit of these rules will not receive promotion.

We shall appreciate and will pay money for suggestions that will improve this system.

UNDER OUR "COST-PLUS-A-FIXED-SUM" CONTRACT

we furnish all superintendence, labor and materials, and complete the project for actual cost plus a fixed sum. To owners desiring speed combined with economy, this form of contract has the following advantages:

The owner's and the contractor's interests are made identical.

The owner knows in advance exactly how much the contractor's profit will be.

The owner's interests require that the work be executed in the shortest possible time at the lowest possible cost and with the best quality of workmanship.

The owner's interests are absolutely identical with those of the contractor in every one of these particulars, because his profit or salary being assured, the contractor's only interest is to perform the work in such a manner as to retain the Owner's patronage.

The owner is relieved of the menace of "extras"—all the work is done at cost. The contractor's fixed sum is in no way affected by the changes in the plans.

The owner has the benefit of all cash discounts for materials.

The owner knows what all materials will cost before they are purchased.

The owner gets the benefit of the lists of materials we have on file which the various dealers have in stock ready for immediate delivery.

The owner has the advantages derived from accurate schedules and shop drawings made for our purchasing department.

The owner has the use of our purchasing department, which is constantly in touch with the best class of sub-contractors and material dealers in several cities.

The owner can purchase the materials if he so desires.

The owner can have his excavation and foundations completed while plans for the superstructure are being drawn.

The owner, Engineer or Architect can make changes and alterations at any time without delaying the work.

The owner has the benefit of the saving occasioned by special designs for all kinds of labor saving devices.

The owner can have any number of skilled and carefully trained mechanics massed on his contract at a moment's notice.

The owner has at his command our mechanical and steam engineers, and riggers for unloading and

setting all kinds of engines, boilers, pumps, machinery, shafting, piping, generators, conveyors, etc.

The owner, Engineer and Architect have at their command the services of our specially trained staff of civil, mechanical and concrete engineers.

The owner knows what the contractor's profit is to be, from the very outset of the work. It is the same amount irrespective of the cost of the work, and there is, therefore, no incentive for the contractor to produce anything but substantial and economical work.

The owner has his building at a minimum cost.

The owner has his building completed as rapidly as is consistent with good workmanship.

The owner, or his authorized representative, has access at all times to all matters pertaining to the work.

Every superintendent and foreman should use special efforts at all times to secure the greatest speed and at the same time be economical.

Speed is more often secured by organization than by crowding the work with a large number of men.

There is no way that speed can be obtained so easily, with so little confusion, and with so little trouble to the superintendent and foreman as by dividing the job into several portions and then by dividing any one kind of work into several similar portions, placing a working foreman and the same number of men on each portion.

Workmen like athletic contests and will enter into the spirit of them quite as quickly and with the same

spirit of rivalry as a college trained team. Therefore, the men will be interested in their work to a larger extent if it is understood at the time that the several gangs start on the several pieces of work that there is to be an athletic contest.

Contests of this kind not only give great speed and reduce cost, but they also enable the superintendent to recognize foremen and mechanics of ability and promote them to higher positions.

In carrying out this scheme, careful attention must be given to the following points:

- (a) The work should be divided into similar portions and conducted under approximately the same conditions.
- (b) The same number of men should be on each portion.
- (c) The same amount and kind of plant should be utilized on each portion.
- (d) It has been found advisable in some cases to arrange the men in accordance with their nationality or other bonds of sympathy.
- (e) Recognition in the form of promotion or increase of pay to the working foreman whose men do the most and best work.

An increase of 20 per cent in the total day's work was the result on one of our jobs because the superintendent permitted the pile driver gang that drove the most piles one day to float their country's flag from the top of the machine all the next day.

When contests cannot be forced by pride of victory alone, the reward of an extra half hour or hour to each member of the winning gang has been found very effective. On one of our jobs it was found that an extra hour to the winning gang unloading cars of brick cut down the total labor expense nearly 50 per cent.

Example No. 1: If two brick walls can be started at the same time with the same number of bricklayers and laborers, the men will undoubtedly lay more brick than they would if no athletic contest were taking place. It is advisable also to place an even number of men on each wall so that the same number will be on each side of the team, and there can then be made a contest to see which side lays out its line first.

Example No. 2: If a concrete wall is to be constructed, it can generally be divided up into rows of columns and bays, and if the same number of rows of columns be given to the same number of men and careful statistics kept as to which one can set up the most columns in a given time, there is no doubt but that more work can be accomplished in competition than otherwise.

Example No. 3: If brick piers are to be constructed in a basement, there should be at least as many bricklayers start as there are rows of piers. They should all start at the same time and the piers should be divided up preferably by rows, so that when a bricklayer has finished his pier, instead of taking the first pier that comes along he takes the next pier

in his row, so that the extent of the contest should be one entire row of piers for each man.

By careful study a superintendent can divide up nearly every part of his work on this basis. By so doing, there will be less trouble for the foreman in charge. Money will be saved for the Owner. More speed will be obtained, all of which will tend to increase if possible the popularity of **"Cost-Plus-a-Fixed-Sum"** method of contracting.

GENERAL RULES

- 1 A copy of this *Field System* must be kept in the office on each job.
- 2 Address all communications to *Frank B. Gilbreth*, and not to any other name. They will then be attended to promptly and not treated as personal mail.
- 3 Notify office of *accidents* at once by telephone or telegraph if accident is serious. Accident blanks must be filled out, the original mailed to insurance company's agent, and the duplicate to New York Office at once.
- 4 Sign "*received*," with name and date on the back of all plans, details, drawings or sketches (stamp in the middle of the plan if possible), regardless of where or from whom the plans are received. This will prevent the substitution of blueprints from altered tracings.
- 5 Provide every convenience for Owners or Officials who inspect your work.
- 6 To prevent confusion, Superintendents must do business through the Architect or Engineer—*not* with the Owner direct.
- 7 Estimates are not to be given by anyone, at any time, without first consulting the Office.

- 8 Foremen, Superintendents and Timekeepers should ask the Office for schedules of lumber, hardware, iron, etc., to assist in checking up the material when it is received.
- 9 Dimension stone, window and door frames, and steel, should be checked for dimensions upon arrival at the job. Make full report of material received in damaged condition.
- 10 Notify Office of shortages of windows, doors, steel, stone, etc., as early as possible, to avoid *waiting* later.
- 11 Get receipts for all money paid and stock delivered.
- 12 When buying brick, remember that for every $\frac{1}{8}$ " that one make of brick is longer than another it is worth about 10 cents more per 1,000. For every 1-16" that one make of brick is thicker than another it is worth about 20 cents more per 1,000.
- 13 Consult Office about itemizing workmen's time so that costs may be compared with similar jobs and with our estimate book.
- 14 Every Superintendent starting a job shall write to the Office for definite instructions as to just what action to take in regard to accidents to our employees.
- 15 When men are wanted, ask the Office. We have men calling at the Office every day, and can sometimes send them to a job at once. Do not, however, depend upon the Office—get the men yourself if possible.
- 16 Do not bother the Office unnecessarily.

- 17 Get from foremen and workmen the names and addresses of men in other trades who would be good men for us.
- 18 *Union* laborers are to be given preference at all times, but no nonsense is to be taken from them.
- 19 *Business agents of unions* are to have full opportunity to consult job stewards. See that they confine themselves strictly to business.
- 20 Any one of our employees found guilty of disobeying any Rule in the *Field System* must render an explanation in writing. This explanation will be filed, so that we may find out those who make the least mistakes and those who do not understand the Rules.
- 21 Ignorance of the Rules in this *system* excuses no employee.
- 22 No employee is to sign any agreement with any *labor union* without written permission from F. B. G.
- 23 *Blow one blast of whistle* at 5 minutes before starting time.
Two blasts at starting time.
One blast at quitting time.
Blasts of whistle to be not over 4 seconds long.
- 24 All men are expected to quit work at quitting time as promptly as they began work.
- 25 Keep duplicate engine bells on the job to avoid delay in case of a breakdown.
- 26 No smoking is allowed on the job except to finish noon smoke—not over one half hour—and no refilling of pipes. All steady pay men must see that this rule is fully enforced.

- 27 On all jobs where there is a temporary privy or a permanent closet, there should be kept a small can of chloride of lime. This can best be handled in one pound cans. Common lime is often used as a disinfectant, but is less effective and costs more.
- 28 *No employee is to sign an agreement* with anyone which will place upon this firm any legal liability. By this is meant rights-of-way across land, use of buildings, etc.
- 29 When placing *builders' risk fire insurance* be sure that our plant is covered, as well as the building. Also see that the fire insurance policies include lighting and earthquake clauses.
- 30 Superintendents, foremen and timekeepers are to provide themselves with transit, steel tape, plumb bob, and Sargent steel square graduated in twelfths and sixteenths.
- 31 Our *office force of civil, mechanical, and concrete engineers* can be had to lay out work or assemble machinery.
- 32 When a job is completed, superintendent and timekeeper must see that all plans, letters, papers, manifold books, etc., are returned to Office, and that all White List cards have been made out.
- 33 Take advantage of *average freight service* wherever possible. This system, which is in force on most railroads, is as follows:—If the usual time allowed for unloading cars before demurrage is charged is 72 hours, we are allowed an average of 72 hours for all cars (under this system). That is, if we save 24 hours by unloading one car in 48 hours, we can

have this time credited to us on some other car and thereby have 96 hours to unload that car before demurrage charges commence.

34 When piling lumber :

Leave wide spaces between the boards or planks, so that they may dry more quickly.

Give the top layer considerable pitch, so that water will drain off.

Turn the top layer over frequently to prevent curling.

35 Do not allow timber to lie in the sun unprotected ; it causes checking.

36 When sending a piece of plank to the mill as a gauge for the working of splines, cut it out of the middle of the plank and not from the end. The ends of a plank shrink more than the rest, and splines worked to an end gauge will not fit.

37 The carpenter with the best tools should be given preference on all work, if other qualifications are equal.

38 When ordering new tools or arranging for the rental of plant, give preference to the Contractors' Machinery Rental & Transportation Company, if their prices are equal to those of other parties.

39 The Superintendent will be held strictly responsible for the transit, rod, etc., sent to the job from the office, and, at the completion of the work, to personally see that this is sent to the New York Office, and a proper record of it made in the Daily Letter.

BATTER BOARDS

40. *Batter boards* should be planed on at least one side and set with the planed side toward the building. They should all be level in themselves, level with each other, and, if possible, level with some particular part of the building, such as: Top of floor timbers, top of finished floor, or top of underpinning, or at even feet of *city grade* (such as 18'0"). They should have pencil lines carefully plumbed and labeled similar to the following:—

“Outside line of footing;” “Outside line of foundation wall;” “Outside line of brick wall;” “Inside line of brick wall;” “Inside line of foundation wall;” “Inside line of footing.” *A little extra money spent on batter boards will not only facilitate the work but is good insurance against mistakes.*

41. A few bundles of strapping may often be used to advantage as measuring poles, measuring sticks for masons, etc. Order some when getting first load of lumber for batter boards.

ADDITIONS AND CHANGES

- 42 Changes from the original plans and specifications must be ordered by the Architect or Engineer *in writing*. Insisting upon this rule may cause a battle, but it is best to have the battle *before* the expense is incurred,—not *after*. *No exception* to this rule is to be made in favor of any Architect or Engineer.
- 43 Ask the office for numbers to be assigned to subdivisions.

TELEPHONE

- 44 The *telephone* is to be placed so that the person using it can look out on the work while waiting.
- 45 *Long distance telephone calls* must be recorded. Get blank form for this from the Office and hang beside the telephone.
- 46 Post on the outside of the locker the location of the nearest *fire alarm box*.
- 47 Post near the telephone the *call numbers* for the *hospitals, ambulance, police* and *fire department*.
- 48 Make sub-contractors pay their proportion for use of telephone.

PRIZES FOR SUGGESTIONS

We desire to secure improvement in all departments of our business, and to this end have adopted a plan whereby employees and others may have an incentive to make suggestions with the assurance that all such suggestions will have careful and impartial consideration. Should such suggestions prove of value, the suggester will thereby qualify to compete for a series of prizes to be awarded monthly to employees offering the best suggestions.

Suggestions are invited from all classes of employees. No suggestion need be held back because it appears to be of little importance. The simplest ideas are often valuable.

Suggestions lead to promotion and increased value. They show an interest in our work and organization, and a capacity for greater responsibilities. We invite suggestions upon methods or equipment, methods which will cause more speed, economy or better work, and other matters calculated to advance the interests of the business.

RULES COVERING SUGGESTIONS

All suggestions submitted will be under the supervision of Frank B. Gilbreth, personally.

Write your suggestion and mail it to F. B. G. marked "personal."

Suggestions will be considered promptly. For each suggestion that is accepted, the Company will award the suggester the sum of one dollar, which will be sent to the employee when he is notified that his suggestion has been accepted. We will then be at liberty to adopt the suggestion at any time at our option.

PRIZES

We will award monthly the sum of \$20.00 for the most valuable suggestions received during the previous month. This amount will be divided as follows:

FIRST PRIZE	-	-	\$10.00
SECOND PRIZE	-	-	5.00
THIRD PRIZE	-	-	3.00
FOURTH PRIZE	-	-	2.00
			<hr/>
			\$20.00

METHOD OF AWARDED PRIZES

On the first Monday of each month, employees who have made suggestions of the greatest value during the preceding month, will be awarded prizes in the order of the value of the suggestion.

As soon as the awards are made, the prizes will be paid in cash, and notices will be posted giving the names of the prize winners, together with a brief description of their suggestions.

Per Order

FRANK B. GILBRETH

Get a copy of this poster and tack it up on the outside of the office.

RULES FOR SUGGESTIONS AND REPORTS

- 49 Reports are requested on the first day of each month from everybody in our organization desiring promotion and are to contain suggestions—particularly in their own Department—as to how work can be done better, more economically, and quicker; how better service can be rendered to our customers, and how more jobs can be secured,—or any other suggestions that will tend to promote our business.

RUBBER STAMPS

- 50 The front side of handles of rubber stamps used in the office must be cut off flat, so as to avoid putting stamps on upside down.

SIGNALS

- 51 Use the following signals for *elevators*:
- 1—*Stop (Emergency)*
 - 2—*Up*
 - 3—*Down*
 - 4—*Down slowly*
- 52 Use following signals on Boom Derrick:
- Emergency stop
 - — Raise on hoisting fall
(hoist behind)
 - — — Lower on hoisting fall
(lower behind)
 - Slack out on hoisting fall
(only when all gone)

_____ —	Raise on boom fall
_____	Lower on boom fall
— — _____	Hoist behind and lower boom
— — — — —	Lower behind and raise boom

SIGNS

- 53 The sign "*Frank B. Gilbreth*" is to be put where it will be the best advertisement.
- 54 A portable sign "*Frank B. Gilbreth*" is to be used when taking photographs of "different views of the job" where the other "F. B. G." signs do not appear.
- 55 The following signs will be furnished on application to the Office:—

**No Admittance to Engine House
Conversation with Engineer
Sufficient Cause for His Discharge**

No Admittance.

**These Elevators Are Dangerous
Riding on Them Forbidden
Anyone Riding on Them Does So
at His Own Risk**

This last sign to be attached to the elevators.

STEADY PAY MEN

- 56 All steady pay men must arrive on the job before the first whistle is sounded, and must remain on the job until quitting time, regardless of weather, but men will not get time for hanging around the office and reporting for duty. They must actually be at work at such things as are mentioned below.
- 57 The intention of the above is to abolish the past customs regarding steady pay men, and applies to everybody, from the Superintendent down to the Apprentice Boy, inclusive.
- 58 Foremen and timekeepers must report to the Superintendent before starting or before leaving work.
- 59 Apprentices are subject to all the rules of Steady Pay Men.
- 60 When work is stopped by bad weather Steady Pay Men shall keep busy, if there is no other work for them, at the following:
- A—Making trestles and patent horses.
 - B—Repairing wheelbarrows.
 - C—Repairing hods.
 - D—Mending hose.
 - E—Repairing engine houses and locker.
 - F—Putting handles in tampers.

- G—Cleaning up tool house.
- H—Cleaning transits.
- I—Preparing staging and runs.
- J—Sharpening saws.
- K—Sawing off handles of worthless shovels.
- L—Checking up lines and levels.
- M—Checking up for dimensions—all steel, window and door frames, dimension stone, etc.
- N—Cleaning and oiling steel tapes.
- O—Cleaning roof, so that rain will not wash rubbish into conductor pipes.
- P—Brushing off sills and projections, so that mortar will not make stains from rain.
- Q—Cutting arches and other fancy brickwork.
- R—Stamping and branding tools. Brands should not be heated too hot; if heated more than just enough to show red, the letters will burn off.
- S—Examining lime to see that little or none is in powder.
- T—Examining cement to see if "*condemned*" has been erased from barrel or brand.
- U—Piling cement and lime at least 6" above the ground.
- V—Seeing if cement and lime are getting wet.
- W—Packing cement bags.
- X—Cleaning mortar from projections before it is set.
- Y—Covering masonry projections to prevent chipping by falling brick.

- 61 Pack cement bags laid flat, one on top of the other, in piles of 50. They can then be counted easily. We lose money by claims of short count when bags are returned. Apply to *office* for special tags and shipping directions. *Freight* must be *prepaid* when cement bags are returned, and *bills of lading* must be obtained in *duplicate*, or we shall not be able to obtain credit for the shipment.
- 62 Pile cement and lime in the store-house so that the oldest will come out first.
- 63 Superintendents and foremen have authority to make such tool boxes as may be needed for storing small tools, such as dolly rolls, drills, points, chisels, hammers, saws, axes, boring machines, etc.
- 64 Timekeepers will be held responsible for any shortcomings of Superintendents, and vice versa.
- 65 *Apprentice boys* should be worked to their full capacity. Help them in every possible way to learn and get promoted. Answer all their questions about work and plans, that are asked in good faith.
- 66 *Every superintendent, timekeeper and steady pay man must suppress subscriptions for presents, and all other forms of graft.*
- 67 *All steady pay employees*, whether on the job or in the office, must keep the office notified of their *addresses* at all times. This rule also applies during vacations.
- 68 Foremen masons and foremen carpenters should each go out of their way to accommodate the other, and should grant the requests of each other promptly.

- 69 Foremen masons, foremen carpenters, foremen plasterers, and timekeepers, *must work in harmony*, because all steady pay men receive credit or blame according as the conduct of the job is good or bad. Teamwork and sacrifice hits are often more effective than "grand-stand plays."
- 70 We have in the past been awarded much work on the basis of *cost-plus-a-fixed-sum*, because we have the reputation of handling such work as if it were lump-sum contract work. *Maintaining this reputation* is the best service which can be rendered this firm, as we try to merit the award of contracts to us without *competition*.
- 71 Our steady pay men are the representatives of our firm: Therefore, their private character and their conduct outside of working hours will be counted in considering promotions.
- 72 Superintendents are expected to handle their work with such skill, promptness and efficiency that we shall continue to merit such unsolicited letters as the following:

HOLLIS FRENCH & ALLEN HUBBARD

CONSULTING ENGINEERS

Albany Bldg., Boston.

Mr. F. B. Gilbreth, November 8, 1902.
Federal Street,
Boston, Mass.

Dear Sir:—

We are very glad to be able to write you that the work which you have done for us on a basis of cost plus commission, notably in the work of altering the hotel at Bellows Falls and enlarging the power

station canal at Garvins Falls has been most satisfactory.

The systematic way in which your accounts are rendered, and the prompt and efficient service which you have invariably given us has been a source of gratification to ourselves as well as to our clients.

Yours truly,

HOLLIS FRENCH & ALLEN HUBBARD

OILS, EXPLOSIVES AND ACID

- 73 Dynamite must not be stored in the tool house. Store it at a safe distance from the building, where an explosion will do the least damage. Mark the buildings "*Dangerous.*" Fly a red flag from the *dynamite and powder shed.*
- 74 Dynamite buried in a box of fresh manure will not freeze.
- 75 Thawing dynamite by placing in hot water decreases its strength.
- 76 Exploders should not be stored near dynamite.
- 77 Gasoline barrels should be covered with oilcloth or wet bags to prevent evaporation, which is often a large item.
- 78 Gasoline is never to be stored inside of a locker, building, or tool house.
- 79 Use sand to put out burning oil, tar, asphalt, or gasoline.
- 80 *Acid* is not to be taken into the locker. The fumes from acid will destroy ropes and cause accidents.

CARE OF TOOLS AND MACHINERY

- 81 Brand and stamp all tools as soon as received.
- 82 All tools, especially concrete mixers, are to be kept at all times in *perfect repair*.
- 83 Small tools and small fittings should be kept in a tool box.
- 84 Keep various parts of machinery together, such as handles, hose, etc., for mixers; handles, clappers, hose wrenches and strainers, for pumps; crab handles for derricks, etc., etc.
- 85 Foremen masons and carpenters must see that all plumb rules and spirit levels are maintained accurate.
- 86 Make home-made ladders, when convenient, double size, i. e., with three or four joists, so as to permit workmen to pass on the ladder. Rungs should be exactly 1'-0" from top to top.
- 87 Worn out shovels should have the handles sawed off, so that they cannot be used; or they may be given to engineers for firing. Shovels cost 75 cents each; enough more work can be done in a short time with new shovels to pay for them.
- 88 When suction hose is destroyed, save the couplings.

- 89 Tools and machinery when shipped away should be complete and in working order.

PHOTOGRAPH SYSTEM

- 90 Photographs are useful as follows:

For keeping Office employees in touch with the conditions on the jobs.

For records of adjoining buildings. Photographing the cracks over the doors and windows and in other places, before we start work, and again after our building is completed, will show whether or not there has been any settlement due to our work.

For records in case of a law suit, discords, or misunderstanding.

For advertising purposes.

- 91 In all cases we want to have the men taken while they are at work and not standing up, posing for a picture.

- 92 If possible keep all bystanders out of the picture.

- 93 As soon as a film is taken, mark on the outside of the wrapper that surrounds it the contract number, the date on which the picture was taken, and the name of the person taking the picture, and send the film thoroughly wrapped up, so as to exclude the light, to our regular photographer.

- 94 Photographs of conditions made at the time of an accident are always particularly important.

- 95 Unless otherwise directed, at least one roll of films should be taken on each job each week, and all pictures on that film should be taken on the same day.

- 96 It being desirable that the sign "*Frank B. Gilbreth*" appear *on all photographs*, it will be necessary for every job to be provided with a portable sign which can be moved from place to place when taking photographs.
- 97 The Superintendent will be held strictly responsible for each camera sent to the job, and at the completion of the work to personally see that it is sent to the New York Office by express, with a proper record of it made in his Daily Letter.
- 98 Use the films that are made to fit your camera, and no others.
- 99 Load your camera in a shady place. The edges of the films are liable to be light struck if the camera is loaded in the sunlight.
- 100 Don't point the camera toward the sun at any time, or let the sun enter the lens at the edges at all.
- 101 Unless your camera has a fixed focus, carefully estimate your distance between the work to be photographed and your camera, and set the focus.

SNAP SHOTS

- 102 If you must take snap shots, take them only when the sun is shining or the day is very bright.
- 103 In snap shots, hold your camera firmly against your body and do not jar the camera when you press the button.
- 104 In snap shots, use the largest diaphragm opening, and so let in all the light possible.

- 105 Do not take any snap shots indoors. It cannot be done with any success with ordinary lenses.
- 106 Do not take snap shots after the sun has set or in the early morning. From 11 A. M. to 2 P. M. is the best time.

TIME EXPOSURE

- 107 Always make time exposures unless there are men or teams working. These will give you the best results for work where detail of building is required.
- 108 Place your camera on a firm, level support, then use the smallest opening in the diaphragm and expose, say 30 seconds in sunlight, or 5 to 10 minutes on a dull day. (These are very rough estimates, the lens, light, size of opening in diaphragm, having to be considered).
- 109 *Remember!* There is more danger of making your exposure too short than too long. Ninety-nine out of one hundred snap shots are under-exposed.

INTERIORS

- 110 If possible, don't point the camera at windows where bright sun is streaming in or your whole film or plate will be ruined. If you must take an interior from such a position or facing any window, cover the windows with manila paper or draw the shades. Expose in a well-lighted room 1 minute. Expose in a dark or dull room 15 to 20 minutes. (These are very rough estimates.)

PHOTOGRAPHING MOVING OBJECTS

- 111 Use the largest diaphragm opening and quickest speed of the shutter. After each exposure wind up your film before you do *anything else*, and so avoid making two exposures on one film.
- 112 Write clearly the contract number and date of taking photograph on the roll of film, after it is sealed.
- 113 Orders for taking photographs must state that the plates are to be delivered to us with photographs.
- 114 On out of town work, mail the prints to the Office, and express the negatives promptly to our regular photographer, as directed.
- 115 All negatives to be dated and numbered.
- 116 Prints not to be mounted.
- 117 Shiny Velox paper to be used for all prints.

NUMBERING AND DATING PHOTO-GRAPHS

- 118 The following notation is to be used on all photographs, the proper Contract Number, Serial Number and date being inserted in the place indicated:
- 119 By our regular photographer, as follows:
A31 - 32 - 5/16/06.
- 120 By the job, when taking photographs which are developed before going to our regular photographer:
A29 - J32 - 4/20/07.
- 121 By special inspector or others:
A28 - B21 - 5/20/06, and in no other way.

- 122 Care must always be taken to use the "J," "B" or other serial letter, so as not to duplicate pictures already taken.

SUPPLIES FOR STARTING NEW CONTRACT

- 123 When starting a new job, the Superintendent or the Timekeeper should get at once from the Office the following:—

TB. (Time Book)
M. (Material Book)
CR. (Cost Report)
DL. (Daily Letter)
O. (Order Pad)
R. (Purchase Requisition)
PR. (Pay Roll Order)
T. (Teaming Tickets)
TL. (Tool List)
QL. (Quotation List)
Record of Telephone Calls.
C. (Cash Account)
Letter Heads.
P. (Partial Shipment Pad)
Expense Blanks.
Masons' Line.
Business Cards.
Paymasters' Requisitions.
Discharge Slips.

Field System.
Accident Blanks.
Brass Numbered Checks.
White List Cards.
Rubber Stamp: "*Prices correct, etc.*"
Rubber Stamp: "*Cr.*"
Confirmation Telegram Blanks.
Pay Envelopes.
Suggestion Blanks.
Prize Suggestion Notices.
Large and small envelopes.
Ink Pad.
Signs, "Frank B. Gilbreth," "No Admittance to
Engine House," "These Elevators are Dan-
gerous," etc.
Special Accounting Instructions.

PERMITS

- 124 Permits to occupy the sidewalk and street can be obtained promptly by applying at the City Hall.
- 125 Permits to cross streets with a guy are obtained by application to the Board of Aldermen.
- 126 Anyone in our employ may apply for a permit.
- 127 Plans showing all water and sewer pipes in the street can be seen at the Water and Sewer Departments.

TABLES AND FORMULAE

- 128 The following data will be of use in making a rough check on quantities:

<i>Granite</i>	measures 12 cu. ft. to the ton
<i>Crushed Granite</i>	measures 20 cu. ft. to the ton
<i>Broken Stone</i>	measures 20 cu. ft. to the ton
<i>Sand</i>	measures 20 cu. ft. to the ton
<i>Coal (soft, broken)</i>	measures 40 cu. ft. to the ton

- 129 To find the weight of *round iron and steel*:—
Square the diameter in quarter inches and divide by 6. The result will be the weight per linear foot.

- 130 To find the *weight of cast iron plates*:—Multiply the length in inches by the width in inches by the thickness in inches and divide by 4. The result will be the weight of the plates in pounds.

- 131 To find the feet *board measure* in a stick of *timber*:—Multiply the width in inches by the thickness in inches and divide by 12. The result will be the feet board measure per linear or running foot of the stick.

See also pages 116, 117, 118, 129, 130, 136, 148, 149, 150, 161, 167, 168 and 169.

MANIFOLD BOOKS

- 132 Manifold books must be kept up to date.
- 133 Manifold Book sheets must be sent to the Office within one day from the date of filling out, whether void or not.
- 134 Manifold books and *letters from the office* must be kept under *lock and key*.
- 135 Manifold book sheets must be filled out with special care and accuracy, as they are shown to Engineers and Architects as vouchers.
- 136 Be sure to always place the Contract Number in the space provided for same on all manifold forms.
- 137 Fill out *sub-division* space on all Manifold Book sheets that are used for *extra work*. This is important, for if it is not done, the work will not be charged to the right account. If you do not know the Number of the *sub-division*, write "*extra work*" in the "*sub-div.*" space, and if possible, write on the sheets what part of the work is referred to.
- 138 "T" tickets must be given at the time the goods are delivered or not at all.
- 139 If satisfactory duplicate tickets are provided by the teamster, sign them and keep one copy for checking bill.

- 140 Unless teamster provides satisfactory duplicate tickets, give him a "T" ticket properly made out.
- 141 *Never give two tickets for the same goods.*
- 142 Never give "T" tickets when "O" is marked "received," as you might check two bills for the same goods.
- 143 "T" ticket and "O's" are used to check bills; "O's" check prices, but not *receipt* of goods unless specially marked "*received*;" "T" checks the quantities received.
- 144 When giving a "T" ticket for receipt of a Partial Shipment on any "O," you are to place the "T" number on the Partial Shipment blank.
- 145 When teaming is done by the hour, state on the ticket the number of hours to be charged.
- 146 When a "T" ticket is given for stock or material used for *extra work*, the *sub-division* space must be filled out. If you do not know the number of the "*sub-div.*," write "*extra work*" in the space. If this is not done, the ticket will not be charged to the right account.
- 147 Measure all stock delivered to us, whether bought by weight or measurement. This applies particularly to *sand, broken stone, granite, slate pinnars, loam and gravel.*
- 148 Count enough loads of brick and measure enough loads of lumber to insure receiving full count. Special attention should be given to loads that appear under size.

- 149 If loads are short, write the name of teamster, number of cart, and amount of shortage on the ticket for the load.
- 150 Give teamsters full opportunity to measure loads with our men. In case of disagreement as to the height of any load, have the top leveled off, so that the measurement may be accurate.

WHERE MANIFOLD FORMS ARE TO BE SENT

- | | | |
|-----|-----|--|
| 151 | TB. | White copy to Accounting Department.
Yellow copy to Owner. |
| 152 | M. | White to Accounting Department.
Yellow to Owner. |
| 153 | CR. | White, Pink and Yellow to Accounting Department. |
| 154 | DL. | White and Yellow to New York Office, unless otherwise instructed. |
| 155 | O. | White to Dealer.
Green to Purchasing Department.
Yellow to Accounting Department.
Pink to Job for reference.
Blue to Job for checking bills. |
| 156 | R. | Green to Purchasing Department.
Pink to be retained on job. |

- | | | |
|-----|----------------------|--|
| 157 | T. | White to teamster.
Yellow for checking bills. |
| 158 | PR. | White copy to Owner attached to Cash Account.
Yellow copy to be sent to Owner with TB. Sheets to which they apply. |
| 159 | TL. | White and Pink to man who will receive tools.
Yellow copy to Boston Office. |
| 160 | Cash Account. | White Copy to New York Office.
Yellow copy to Owner. |
| 161 | P. | Green to Purchasing Department.
Blue to check and to attach to original bill.
Yellow to be attached to duplicate bill. |
| 162 | Final Shipment Stub. | Pink to Purchasing Department.
Blue attached to (original) final bill.
Yellow attached to (duplicate) final bill. |

DAILY LETTER (DL.)

- 163 Daily Letter must be written by the Timekeeper and countersigned by the Superintendent, and must state the general conditions and progress of the work.
- 164 Both copies of the Daily Letter are to be sent to the *New York* Office each day, unless otherwise instructed by the Office.
- 165 Special attention must be given to the importance of filling out every space in the left hand column.
- 166 Intelligent information must be given in every space.
- 167 When calling the attention of any individual or department at the Office, use a separate "DL." for each one, marking name or initials in large letters after "*attention of.*"
- 168 When answering a letter from the New York Office, place the initials of the writer after "*attention of*"—at the head of the "DL."
- 169 Do not have the initials of two individuals appear on one "DL.," but use a separate "DL." for each individual or department.
- 170 Do not call the attention of any individual in the general "DL."

171 Timekeeper and Superintendent will be held jointly and severally responsible for the *accuracy* of the *daily letter*, for its compliance with the *field system*, and for the omission of any information which the Office should know.

172 The *daily letter* should cover fully the following points:

A—Shortages of stock as compared with *tickets*.

B—An early and complete statement when stone, steel, or other stock does not check with plans, schedules, or specifications.

C—Delays to work due to bad weather, lack of plans, or other causes.

D—Delayed instructions or plans received from the Owner, Architect or Inspector.

E—A general statement of what work has been accomplished.

F—A statement when important pieces of work have been completed.

G—Suggestions as to how work can be done faster or more economically.

H—A statement of how the Office can assist to rush the work.

I—Confirm verbal orders from Owner, *Inspector* or Architect.

J—Number of masons employed and laborers tending them.

K—Number of bricks laid per hour per mason.

L—Total number of bricks laid per day.

M—Number of carpenters employed.

RULES FOR DAILY LETTER. ADDRESS ALL LETTERS TO FRANK B. GILBERTH. D. L. MUST BE WRITTEN BY TIME-KEEPER AND SIGNED BY TIME-KEEPER AND SUPT. BOTH TIME-KEEPER AND SUPT. WILL BE HELD RESPONSIBLE FOR ACCURACY OF DAILY LETTER AND FOR OMISSION OF FACTS THAT OFFICE OUGHT TO KNOW. EVERY ONE OF THESE SHEETS MUST BE ACCOUNTED FOR. SEND OFFICE COPIES TO THE OFFICE WHETHER SPOILED OR NOT.

READ FIELD SYSTEM, RULES 1 TO 6 INCLUSIVE, FOR FURTHER INFORMATION.

ATTENTION OF

Every space in this column must be filled out, or no promotion will be made.

Do you
know
for

Do you
know
for

Place
Worked

Do you
know
for

Do you
know
for

Changes in Plans
or Specifications
Ready To
Show Let's and
know what they are
for

Do you
know
for

Do you
know
for

Do you
know
for

N—Names of steady pay men and time any one of them is late.

O—A statement of how much cement is wholly or partly caked, and who is to blame.

P—A statement of carloads of stock received, giving initials and number of car, and contents of car.

Q—Enclose office copies of manifold book *tickets* and stock *tickets*.

R—Enclose *White List cards* for each *good* man leaving us.

S—Condition of weather and temperature at 8 a. m., 12 noon and 4 p. m.

- 173 *Caution:* Do not recite in *daily letter* the receipt of stock for which you have enclosed *tickets*.

TEAMING TICKETS (T)

- 174 When we deliver goods to another party, cross out "*Frank B. Gilbreth*" on a "T" ticket and have the party receiving the goods sign his own name instead. Give him the white copy and keep the yellow copy for reference.

- 175 When condemned lumber, brick or cement, is hauled away, make the teamster sign a "T" ticket, made out as directed above, so that we can get credit for the goods.

- 176 Teaming tickets are to be signed:

(OWNER'S NAME).....

FRANK B. GILBRETH, AGENT FOR OWNER.

BY.....

EVERY ONE OF THESE SHEETS MUST BE ACCOUNTED FOR. MARK EVERY SHEET VOID THAT HAS BEEN SPOILED. SEND EVERY OFFICE COPY TO THE OFFICE WHETHER SPOILED OR NOT. COPIES TO BE RETAINED IN THIS BOOK MUST BE PRESERVED WHETHER SPOILED OR NOT.

THIS COPY IS FOR THE TEAMSTER.

FRANK B. GILBRETH, GENERAL CONTRACTOR

NEW YORK

34 W. 26TH ST.

DELIVER NO GOODS WITHOUT A TICKET. NO CHARGES FOR STOCK OR TEAMING WILL BE ALLOWED UNLESS ACCOMPANIED WITH THIS TICKET.

THIS CERTIFIES THAT THERE HAS BEEN TEAMED FOR US

TEAM'S

NAME

DATE

190

KIND OF MATERIAL

SINGLE.

— X

DOUBLE.

— X

HOURS.

TOTAL
CUBIC
FEET

CHARGED ON M.

CON. SUB.

NO. DIV.

CAR NUMBER

FRANK B. GILBRETH,
AGENT FOR THE OWNER

BY

FORM N. Y. 12

THIS TEAMING
TICKET IS NO.

T 231

PAY ROLL ORDER (PR)

- 177 Fill out "PR" *ticket* whenever a man is paid off at any time other than at the regular time on pay day, sending the white copy to Owner, attached to Cash Account, and yellow copy to Owner with "TB." sheets.
- 178 After the man has been paid off, place "PR" and the number of the "PR" opposite his name or number, in the Column for "*Remarks*" on "TB." sheets, which shows that the man has been paid off.
- 179 Men paid by "PR" ticket must sign their names on same.

FRANK B. GILBRETH,
GENERAL CONTRACTOR,

NEW YORK,
34 WEST 26TH ST.

DISCHARGE SLIP

DATE.....CON. NO.....

TIME OF DISCHARGE.....

NAME OR NUMBER.....

SUPT. OR FOREMAN SIGN HERE.....

HAND THIS TO TIMEKEEPER AT ONCE WITH BRASS CHECK.

FORM 91-B-30-04-2000

180 When a workman is discharged, the foreman must make out a "Discharge Slip" with the man's number and time of his discharge written on it; this slip to be given to the man discharged, who is then to hand it, with his numbered brass check, to the Timekeeper.

181 A workman discharged cannot obtain his money unless his check is accompanied with a "Discharge Slip."

TIME BOOK SHEETS (TB)

- 182 When men are employed on extra work see additional directions below.
- 183 Time sheets are to be made upon our regular "TB." sheets, the week ending agreed upon.
- 184 Keep all time books with the greatest care.
- 185 *Do not use a note book.* We find that most mistakes in workmen's time are caused by copying.
- 186 All remarks about the payroll must be written on the time sheet itself.
- 187 The full time of every one of our men must appear on the regular *time book* ("TB.") sheets.
- 188 The time of any of our workmen which is to be charged to *extra work* must be entered on supplementary sheets under the proper *sub-division number*. Keep separate sheets for each "*sub-div*" (sub-division) and fill out carefully the "*sub-div*" number and *nature of work*. Send these extra work sheets to the Office as soon as they are signed. If you do not know the number of the "*sub-div*" write "*extra work*" in the space.
- 189 The Timekeeper shall do the figuring on the sheets.

- 190 Total each sheet separately.
- 191 The Timekeeper shall make out all pay envelopes.
- 192 Turn over the Yellow Copy of "TB." sheets with the pay envelopes, and the Yellow "PR's" which show on the "TB." sheets, to the Owner.
- 193 The Owner or his representative shall pay off on pay days.
- 194 Send the White Copies of "TB." sheets to the *New York* Office as soon as the men have been paid off.
- 195 When a workman is paid with a "PR" order, the number of the "PR" must be entered in the time book, opposite his name, in the column for "*Remarks.*"
- 196 State in the *time book* the exact amount of time that *steady pay men work*, regardless of the basis on which they are paid.
- 197 Consult the Office about the wages of *steady pay men*.
- 198 The instructions on "*Paymasters' Requisitions*" must be carried out carefully.
- 199 "TB." sheets should be signed by the representative of the Owner before being sent to the *New York* Office.
- 200 Any envelopes not called for by the workmen at paying off time on pay days are to be kept by the Owner until called for by the workmen.
- 201 When instructed to keep the costs of labor and materials on *extra work* or *subdivisions*, use "TB." sheets and "M" sheets in making up costs.

SEND THIS SHEET TO THE NEW YORK OFFICE.

FRANK B. GILBRETH, GENERAL CONTRACTOR,

THIS ACCOUNT IS CORRECT.

EVERY SHEET IN THIS BOOK MUST BE ACCOUNTED FOR.
MAKE EVERY SHEET VOID THAT HAS BEEN SPOILED.
SEND EVERY SHEET COPY TO THE OFFICE IMMEDIATELY.
SIGNED BY ME, RETURNED IN THIS BOOK MUST BE
RECORDED IMMEDIATELY SPOILED OR NOT.

_____ SUPT.

MAIN OFFICE, NEW YORK,
33 WEST 34TH ST.

_____ TIME KEEPER.

DATE	LAST NAMES PARTY	TRADE	TIME PM	DAY	SE	MON	TUE	WED	THU	FRI	TOTAL HOURS	RATE	AMOUNT DOLLARS CENTS	REMARKS.
1														
2														
3														
4														
5														
6														
7														
8														
9														
10														
11														
12														
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NATURE OF WORK.

FOR WEEK ENDING 100

CON SUB.

NO DIV.

IMPORTANT - CALL OFF THIS SUB. DIV.

THIS ACCOUNT APPROVED

TOTAL

ADD FOR

PER CENTAGE

TOTAL DUE

F.B. GILBRETH

THIS SHEET IS CORRECTED

T.B

THIS TIME BOOK SHEET IS

T.B 102

MATERIAL SHEETS (M)

- 202 The White Copy of the "M" sheet is to be attached to the duplicate bills which make up the "M" sheet, and then sent to the *New York Office*.
- 203 The Yellow Copy of the "M" sheet is to be attached to the original copies of bills, which make up the "M" sheet, and then turned over to the Owner. Bills on which there is a discount are to be handed to Owner immediately after being entered on "M" sheet.
- 204 All "M" sheets to be signed by representative of the Owner before being sent to the *New York Office*.
- 205 All cash items, excepting Pay Roll items, are to be entered on separate "M" sheets.
- 206 Do not hold an "M" sheet on the job because it is not filled, but when entering the "M's" on the Cost Report, enter them all, whether full or not, and send them to the New York Office.
- 207 All material used, whether or not especially bought for *extra work*, must be entered on "M" sheets.
- 208 Pay special attention to charging for material left over from the contract, which is very often used for *extra work* or a *sub-division*.

- 209 *Sub-division* space must be filled out on "M" sheets.
- 210 If you do not know the Number of the "Sub-Div" write "*extra work*" in the space, or a description of the work to which the sheet refers.
- 211 "M" sheets must be dated, properly filled out and approved promptly.
- 212 Be sure that your carbon copies are clear and distinct.
- 213 Always use the same wording in the space for "*nature of work.*"
- 214 Orders in writing must be demanded and received before changes are made from original plans and specifications, whether these changes call for "*extra work*" or not. This will determine the responsibility for changes.
- 215 Send the original written order to the Office and keep a copy for job reference.
- 216 Ask the Office for numbers to be assigned to *sub-divisions*.
- 217 To prevent confusion, Superintendents must do business through the Architect or Engineer—*not* through the Owner.

THIS ACCOUNT IS CORRECT.

SEND THIS COPY TO NEW YORK OFFICE PROMPTLY

FRANK B. GILBRETH, GENERAL CONTRACTOR.

SUPT. _____

MAIN OFFICE,
NEW YORK,
94 W. 20TH ST.

TIME KEEPER. _____

EVERY ONE OF THESE SHEETS MUST BE ACCOUNTED FOR.
MARK EVERY SHEET VOID THAT HAS BEEN SPOILED.

SEND EVERY OFFICE COPY TO THE OFFICE WHETHER SPOILED OR NOT.
COMES TO BE RETAINED IN THIS BOOK MUST BE PRESERVED WHETHER SPOILED OR NOT.

DATE	MATERIAL AND PLANT USED		PRICE APICE		AMOUNT		REMARKS
	BILL NUMBER		DOLLAR	CENTS	DOLLAR	CENTS	
1							
2							

35

36

THIS ACCOUNT APPROVED.

AGENT FOR OWNER.

NATURE OF WORK.

THIS SHEET IS CONTINUED
FROM SHEET NUMBER

M

THIS SHEET IS NUMBER

M15702

IMPORTANT.

FILL OUT THE SUB. DIV.

CON. SUB.

NO. DIV.

FORM. N. Y. 28-500 BOOKS. 1-28-17.

ORDERS (O)

- 218 When "O" form is used on the job, the green and yellow copies are to be sent at once to the *New York Office*.

PINK AND BLUE COPIES OF "O":—

- 219 The Pink Copy is to be kept on file in the office on the job and carefully preserved for reference at any time. The final shipment stub on the bottom of the pink copy is to be filled out and sent to the *New York Office* as soon as the final shipment called for on that particular order is received.
- 220 The Blue Copy is to be attached and used for checking the bill for the goods. The blue final shipment stub on the bottom of the copy is to be filled out at the same time with pink and yellow stub and is to be attached to and used for checking the bill.
- 221 Care is to be taken in filling out final shipment stubs to see that no duplication of the previous part of the order is included.
- 222 A complete description of the goods, together with any shortages, is to be noted in all cases.
- 223 The White Copy is to be sent to dealer, with instructions that bills be sent in triplicate to "*Frank B. Gilbreth*" (*job address*).

- 224 The Blue Copy of "O" is to be attached to original bill after being checked. If the bill only calls for a partial shipment, the blue "O" is to be attached just the same, with the blue partial shipment blank.
- 225 If there are a number of partial shipments on any "O," the blue "O" is to be attached to the first bill, with the blue partial shipment blank which covers the material shown on bill.
- 226 The following bills which may come in, applying to same "O" and which are partial shipments, will have blue partial shipment blanks attached; when the final bill comes in, attach the blue final shipment stub.
- 227 If the first bill comes in calling for the entire "O" and all the material has been received as shown on "O," the blue final shipment stub with blue "O" is to be attached to bill.
- 228 The yellow partial and final shipment blanks are to be attached to the duplicate bills, which are to be sent to the Accounting Department.
- 229 Every duplicate bill is to have a yellow partial shipment blank attached, unless the bill which comes in calls for the entire "O," or the final shipment, then the yellow final shipment blank is attached to duplicate bill.
- 230 Special attention must be given to the importance of placing the "O" numbers in the space provided for same in the "price correct, etc." stamp on face of bill. This applies particularly to the duplicate bills which are sent to the Accounting Department.
- 231 Itemize the final shipment on the final shipment stub, so that the Purchasing Department can see at a

SEND THIS COPY TO CONTRACT TO ATTACH TO AND CHECK BILLS

FRANK B. GILBRETH,
GENERAL CONTRACTOR
NEW YORK,
34 WEST 26TH ST.

TO

DATE,

ADDRESS

SHIP TO

BILL TO

SEND BILL IN

TO

THIS ORDER

FILLS REQUISITION

TO BE USED FOR

PLEASE DELIVER TO US AS AGENTS FOR

WE RESERVE RIGHT TO CANCEL ORDER IF DELIVERY IS NOT MADE AS PROMISED

PRICE

010382

DELIVERED, F. O. B.

DATE OF DELIVERY

SHIP VIA

SUPERINTENDENT AND TIMEKEEPER ARE TO COMPARE THIS ORDER IMMEDIATELY WITH REQUISITION AND NOTIFY OFFICE AT ONCE IF ANY MISTAKES ARE FOUND.

CON.
NO.

SUB.
DIV.

EVERY ONE OF THESE SHEETS MUST BE AN
IDENTICAL COPY. MAKE EVERY SHEET EXACT
THAT HAS BEEN SPECIFIED. COPIES MUST BE
PRESERVED UNLESS SPECIALLY ORDERED OR
ARE RETURNED TO NEW YORK OFFICE.

FRANK B. GILBRETH, AGENT

BY

TEAR OFF THIS STUB WHEN FINAL SHIPMENT IS RECEIVED AND USE FOR CHECKING BILLS

FRANK B. GILBRETH,
34 WEST 26TH STREET, NEW YORK.

FINAL SHIPMENT, AS ENUMERATED BELOW, CALLED FOR ON ORDER **O 10382**

WAS RECEIVED ON

DATE

FROM

BY SHIPMENT NAME

BY

DESCRIPTION

IF SHIPMENT OR SHIPMENT IS SHIPPED GIVE FULL PARTICULARS

DO NOT SEND IN THIS STUB UNTIL COMPLETE SHIPMENT IS RECEIVED
WHEN PARTIAL SHIPMENTS ARE RECEIVED USE FORM NO. 36

FORM N. Y. 270-1240-25 Feb.

CON. NO.	SUB. DIV.
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glance the exact amount of material which was received on the final shipment. If the first shipment calls for the entire "O," the final shipment stub must show all the material shown on "O."

232 If goods are received at the time that the "O" is given, write "*received*" on "O." If goods are not received until later, do not mark "O" but give a "T" ticket with "O" number written on it.

233 Do not in any case mark "*received*" on "O" if any other ticket has been given. If you do, the man could charge for the same goods twice.

234 All "O's" must be signed as follows:
(OWNER'S NAME)
FRANK B. GILBRETH, AGENT
BY

235 When purchasing material, a written Order must be given, no matter how large or how small the order.

236 The price is to be filled in, in every case, even if necessary to hold back the Order until price can be obtained.

237 Fresh carbons are to be used to the extent that will insure perfectly plain copies.

238 Be sure to always specify in the space provided for same on the colored copies of "O," what the material is to be used for.

OWNER'S ORDERS

239 If the Owner orders goods direct on his own order, get three copies of that order, one to be sent to Purchasing Department, one to Accounting De-

partment, the other to be retained on the job for reference. This order is to be handled exactly as though it were one of our own orders, being placed in turn in fifth and fourth columns of cost report until the final bill comes in, calling for the final shipment.

240 Also make out Partial Shipment blanks on Owner's Orders, and, when a final shipment comes in, use a partial shipment blank for the final shipment stub on the Owner's order only. Mark in large letters "*final shipment*" on the Partial Shipment blank, so that we will know it is the Final Shipment.

241 As "O" number cannot be placed in space provided for same on Partial Shipment blank for *Owner's Orders*, it will be necessary to place initials of Owner, and date of order in that space provided for "O" number.

PARTIAL SHIPMENT BLANK (P)

242 Partial shipment blank is to be made out for all partial shipments of material, tools, plant, etc., that are received.

243 No matter by whom ordered, if the complete shipment is received use the final shipment stub.

244 The "P's" are to be made out and sent in every night for all partial shipments received that day.

245 The Green Copy is to be sent to the *New York* Office immediately.

246 The Blue Copy is to be retained on the job to check and attach to original bill.

**SEND ONE OF THESE SHEETS TO PURCHASING DEPARTMENT
N. Y. OFFICE FOR EACH PARTIAL SHIPMENT RECEIVED.**

FRANK B. GILBRETH,

M. AM. SOC. M. E.

34 WEST 28TH STREET, NEW YORK.

PARTIAL SHIPMENT, AS ENUMERATED BELOW, CALLED FOR ON ORDER O_____

WAS RECEIVED ON _____ FROM _____ BY _____

DATE

GIVE SHIPPERS NAME

IF SHORTAGE OR MISTAKE IN SHIPMENT GIVE FULL PARTICULARS

DESCRIPTION

**USE FORM NO. 37C. FOR FINAL
SHIPMENT.
FORM NO N. Y. 36**

CON. NO.	SUB. DIV.	P 543
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- 247 The Yellow Copy to be attached to duplicate bill.
- 248 When a partial shipment of goods is received, the blue and yellow Partial Shipment blanks are to be attached to the pink "O," until the bills come in.

SEND THIS TO PURCHASING DEPT. NEW YORK OFFICE IMMEDIATELY.

FRANK B. GILBRETH,
34 WEST 30TH STREET, NEW YORK.

PURCHASE REQUISITION

INSTRUCTIONS

STATE CAREFULLY ALL DETAILS NECESSARY FOR ORDERING, CATALOGUE NO., QUALITY, DIMENSIONS, ETC., AND IF WANTED ON ACCOUNT OF CHANGES BE PARTICULAR TO GIVE SOURCE OF INFORMATION, DATES OF LETTERS, NUMBERS OF DRAWINGS, AND WHAT CHANGES WILL BE NECESSARY IN MATERIALS ALREADY DELIVERED OR IN TRANSIT.

DATE		SHALL WE SHIP VIA FREIGHT OR EXPRESS	
DATE WANTED AT DESTINATION			
THIS MATERIAL TO BE USED FOR			
ISSUED BY	SUPT. THREKPR.	CON. NO.	SUB. DIV.
		THIS FORM IS R 157	
DO NOT WRITE BELOW THIS LINE			RECEIVED STAMP
FILLED BY O		DATE	
SENT OUT FOR PRICES.			
BY			

FORM NO. 10 FORM NO. 10

PURCHASE REQUISITION (R)

- 249 When material, plant, repair parts, tools, etc., are wanted, a requisition is to be made out, all the spaces being properly filled and a clear description of the article given.
- 250 The Green Copy is then to be forwarded to the office at once.
- 251 The Pink Copy is to be retained on the job for reference and for checking the Order when made out.
- 252 When miscellaneous supplies or material are to be bought by the Owner at the job, give a *requisition* for same.
- 253 Use Purchase Requisitions for *everything* ordered and send them through the New York Office or Owner.

COST REPORT (CR)

- 254 When *Cost Reports* are used on the job, the White, Yellow and Pink copies are to be forwarded at once to the Accounting Department at the New York Office for checking, and from there they will go to their respective destinations. The tissue copy is to be kept in the book, or filed in the office on the job for reference.
- 255 Cost Reports are to be made up weekly and sent in immediately to New York Office.
- 256 In the first column, headed "TB.," enter separately the number of each "TB." sheet, the date and the total amount of each sheet.
- 257 In the second column, headed "M," made up on job, enter separately, the number and total amount of each "M" sheet.
- 258 In the third column, headed "M," made up at Office, enter separately the number and total of each office "M" sheet, which will be given by *New York Office* as often as possible. Do not hold over Cost Reports for Office "M" sheets.
- 259 In the fifth column, headed "Total of Contracts Not Entered," enter all "O's" separately for material which has been ordered, or for contracts of work to

LOCATION:

SEND THIS TO NEW YORK OFFICE

MAIN OFFICE
24 WEST 26TH STREET, NEW YORK CITY

[illegible]

be done, for which bills have not been received. These "O's" are to appear in the fifth column of the Cost Report each week, until a bill comes in. If the bill only calls for a partial shipment on the "O," the order will have to appear in the fourth column, headed "Proportion of Contracts Not Entered," until the final bill comes in calling for the final amount of the "O" shown in the fourth column of Cost Report.

260 After making out the first Cost Report, carry forward the total amount of the "TB.," and place it on the first line of the next Cost Report, in the column headed "TB." Do likewise with totals of column headed "M" made up on job, and "M" made up at Office. By carrying forward the totals each week we will have total "TB." to date, total Job "M" to date, and total office "M" to date. Add these three amounts together, giving total of all three columns entered to date.

261 It is absolutely necessary that all manifold forms be sent together regularly to the *New York* Office, except the forms which are to be sent in as soon as they are made up.

CASH ACCOUNT (C)

- 262 White copies of Cash Accounts are to be sent to the Accounting Department at the New York Office weekly, unless otherwise directed.
- 263 Tissue copies are to be retained in the book or on file in the office on the job, for reference.
- 264 Yellow copies are to be sent as directed by the Accounting Departments.
- 265 Vouchers must be obtained for all cash items, where possible, and attached to cash account when sent in. All cash items, excepting "PR." items, are to be entered on separate "M" sheets before cash accounts are sent in.
- 266 When entering "M" items from a cash account the White Copy of Cash Account is to be attached to the "M" sheet upon which the cash items are entered, then sent to the New York Office.
- 267 In entering items from the Cash Account, the Cash Account is to go through the same course as a bill, placing the "Prices correct, etc." stamp on front of same, and inserting a bill number.

MAIN OFFICE
34 WEST 26TH ST., NEW YORK

WEEKLY CASH ACCOUNT OF CON: _____ WEEK ENDING _____

MADE OUT BY _____ **CHECKED BY** _____ **APPROVED BY** _____

[illegible][illegible]

Page 17.

UNITED STATES OF AMERICA

TOOL LIST (TL)

- 268 Tool List rules must be followed to the letter whenever tools are either shipped to, or received from, the yard or another job, or received from a dealer.
- 269 Tool lists are made in quadruplicate and contain directions for shipping tools. One copy must be sent to the office, and two copies to the man who is to receive the tools at destination. The man who receives the tools will keep one copy and send one copy to our office, after he has written on it a list of the tools shipped which he did not receive.

DIRECTIONS ON PINK AND WHITE SHEETS:—DUTIES OF THE MAN WHO RECEIVES THE PINK AND WHITE COPIES:

- 270 Compare the Pink Copy with the White Copy and see if they agree. If White Copy and Pink Copy do not agree, notify Office, and also the man who shipped the tools, wherein they do not agree.
- 271 Compare the White Copy with tools actually received. Do not change either the Pink or the White Copy, even if they do not agree with the tools actually received.
- 272 Write on the Pink Copy and the White Copy full account of the shortage, giving teamster's name, name

of the man he works for, railroad owning car, and car number.

273 Man who receives these tools will paste this Pink Copy in his own tool list book for reference.

274 Send the White Copy to the Office as soon as the above five rules are complied with; your contract will then stand charged with this corrected list or their value until you ship them to some other job or the C. M. R. & T. Co.

DIRECTIONS ON YELLOW AND TISSUE SHEETS:—DUTIES OF THE OFFICE UPON RECEIVING THE YELLOW AND WHITE SHEETS:

275 Charge destination job with these tools (i. e., file this Yellow Copy under number of job to which tools were sent).

276 Compare the Yellow Copy with White Copy as soon as the White Copy is received.

277 Credit shipping job with the tools of this list (i. e., file the White Copy under the contract number of job that shipped tools).

278 At the completion of a contract charge it with the difference between the Yellow and White sheets.

FRANK B. GILBRETH, GENERAL CONTRACTOR.

MAIN OFFICE NEW YORK
54 WEST 50TH ST.

NOTES OF THE MAN WHO RECEIVES THE WHITE COPY.

- (1) Compare the pink copy with the white copy and see if they agree.
- (2) Follow every step and make copy do not agree finally after all the man who shipped the tools.
- (3) Compare every copy with the tools actually received. Do not change the white copy until the man who shipped the tools is satisfied.
- (4) Write on the white copy the amount of the shortage, giving teamster's name, name of the man he works for, R. R., writing tag, and any money he has.
- (5) Compare the white copy with the pink copy and see if they agree. If not, the man who shipped the tools with your contract will then stand charged with this increased list or their value, until you ship them to some other job or your yard.

SEND THIS COPY IMMEDIATELY TO THE MAN WHO WILL RECEIVE THESE TOOLS.

THE FOLLOWING LIST OF TOOLS WERE SHIPPED

127

FROM _____ TO _____

VIA (GIVE CAR NUMBER AND TEAMSTER'S NAME)

MAN WHO SHIPS THE TOOLS SIGNS HERE

MAN WHO RECEIVES THE TOOLS SIGNS HERE

ALL OF THE FOLLOWING TOOLS WERE RECEIVED AT THE ABOVE PLACE EXCEPT

WRITE THE WHOLE STORY ON THIS SHEET.

THIS TOOL LIST SHEET IS

TL 38 4716

FORM 60-A.

LIST OF TOOLS.

Accurate Measurer and Feeder	Bolts
" Drum	Bolt cutter
" Chutes	Boots, rubber
" Operating Mechanism	Boom bracket
" Concentrating Hopper	Boom slewing wheel
" Forgings & Bolts, set.	Boring machines
Acid	Brand, "Gilbreth"
Absorptiometer (brick soaker)	Brooms, common
Adze, carpenter	" push
Anvil	Brushes, scrubbing
Augers, boring machine dia.	" whitewash
" ship	" wire
Automatic cutoff for water hose	Brass bushings for sheaves
Axe, hand	Burners, paint
" long-handled	Bushings, metaline
	Buckets, hoisting
	" tar
Back stay for derrick	Bull wheel of engine
Barrel, oil	
Bars, crow	Can, oil
" pinch	Cant dogs
Battery, electric	Canvas (approximate size)
" for blasting	Cars, brick
Bells, electric	" industrial railway dump
Bellows, blacksmith's	" standard gauge push
Bin, storage	Carts, tip
Blocks, snatch-clevis	" 2 wheel for concrete
" weighted cheek	" 2 wheel dump
" wood	Chain falls, Weston
" single, in., wire or hemp	" hoist
" double, " " " "	" guy
" iron, " " " "	" with hook & ring long
" single, " " " "	" with two rings
" double, " " " "	" scale box
Boilers, locomotive style	" sprocket, diam.
" upright	" with stone dogs
" horizontal	

LIST OF TOOLS—Continued

Chisels, brick	Dippers, tin
“ cold	“ tar
“ calking	Dogs, stone
“ cape	Dolly bars
“ stone	Drills, blacksmith
Clips, guy	“ machinist's
Coal	“ hand power post
Couplings, brass hose	“ rose
“ iron pipe	“ stone
Cross head to double elevator	“ steam rock drills and tri-
“ “ “ single “	“ pods, complete
Cutters, pipe	
Dead eye	Ejector, Hancock (size)
Derrick boom (length)	Engines, Independent
“ castings and fittings,	“ hoisting 5½x8, No. on
“ complete set	“ boiler
“ Mast top casting	“ hoisting 7x10 No. on
“ “ bottom “	“ boiler
“ Pintle casting	Elevator double single
“ 2 sheave brackets	“ on chimney (size of
“ Guy cap	“ platform)
Derrick, 8 sheaves	“ hod
“ Boom ring	“ bucket
“ 2 plain iron block	“ supports for crosshead
“ 1 weighted cheek block	
“ Falls	Falls, wire, approx. lgth & dia
“ Guys	“ manila “ “ “ “
“ 6 large guy cap shackles	Faucet
“ 20 guy shackles	Files, saw
“ Guy clips	“ flat
“ mast	“ half round
“ spar	“ round
“ foot block	Forge, blacksmith
Derrick pins	“ riveting
Die stock and dies for bolts	Foot valve for centrifugal pump
“ “ “ “ “ pipe	Forks, coke (handle broken
	stone)

LIST OF TOOLS—Continued

Furnace, lead melting
 " asphalt

Gauge, steam
 Gouge

Grates, boiler

Grease for wire ropes

Grindstone

Guys, wire, diam, approx. lgth.

Guy caps

Guy posts, length, size

Hammer, sledge

" hand

" bush

" pean

" striking

Handles, hammer

" hoe

" pick

" maul

" tamp

" hod

Harness for tip carts

Heaters, mortar

" sand

Hods, brick

" mortar

Holding on sledge, riveting

Hoe, ash

" mortar

Hoisting engine grates

Hooks, hinge

" tag

Horses, framing

" trestle

" patent scaffold

Hose, concrete mixer

" water

" suction

" steam

Hose menders

Houses, engine

Increaser, (sizes)

Injector

Inspirator

Jacks, Gilbreth Patent

" Albany

" plain screw

" Norton pat.

" hydraulic

Jointers, granol. walk

Kettles, tar

Ladders (length)

Ladles, melting

Lag screws

Lamp, office

Lanterns

Lewis, stone

Line (mason's)

Lubricators, plain oil cup

" plain grease cup

" sight feed oil cup

" sight feed cyl. oiler

" plain cylinder oiler

Mattocks

Maul, wooden

" pin

Marline

Mast slewing rig

" Bull wheel for derrick

LIST OF TOOLS—Continued

Mast wire falls	Pitch
" drum attach't for engine	Pile drivers
Megaphones	Pitching tool
Mixers, concrete, gravity,	Plank
model serial	" driving cap
" " Gotham pulley style	Pliers
" " Gilbreth rotary with	Plow points
engine	Plow, soft ground
" " Gotham with engine	" hard pan
" " " with engine and	Plumb bob
boiler	Points, stone
" " United Tipping	Pokers
Eng. style	Pulsometer
" " " " with	Punch, beam or plate
engine & boiler	Pump, boiler test
Mops for waterproofing	" diaphragm
Mortar red	" horizontal force
Mortar black	" duplex
Nails	" single
Oil, dead	" steam
" linseed	" centrifugal with engine
Packing, round	" " without "
" sheet	Reducers
Padlocks	Register (brick counter)
Pails, galv. iron	Rippers, staging
" wood	Roll, wood (length)
Paint, black asphalt	" iron (length)
" outside	" block or dolly
" inside	Rope, wire
" fireproof	" falls
Picks	" guy
Pipe, Akron	" lashing
" cast-iron	" manila
" wrought iron	" tag
" spiral steel	Ratchets, machinist's

LIST OF TOOLS—Continued

Saws, cross-cut	Stamp—F. B. G.
“ hand	Steel tape length
“ hack	Stove, office
“ pintle	Straight edges
Salamanders	Stencils
Sash	Strainer for suction hose
Scaffold, Gilbreth patent	Swing stage
Scale box, forgings, sets complete	Tackles
Scale boxes, wood	Tampers, square
“ “ iron	“ round
Scrapers, wheel	Tar paper
“ drag	Thimbles, galv., W. I.
Screens, sand	Tipcarts
“ gravel	Tongs, stone
Screw drivers	“ track
Sheave Brackets	“ blacksmith
Shovels, round	“ chain for pipe
“ square	Tool boxes, engine
“ snow	“ “ pump
“ long-handle	Tool chest (iron bound)
“ coal scoop	Torches, gasoline
Spades	Transits
Shackles	Trucks, freight handler's
Sheaves	Tube cleaner
Shims, wedges	“ expander or roller
Signs	Valves, safety
Slice bars	“ steam
Smoke pipe	“ globe
Spirit level	“ gate
Staging	“ check
“ ledgers	Vise, carpenter's bench
“ plank	“ blacksmith's
“ poles	“ machinist's
“ putlogs	“ pipe
“ outriggers	

LIST OF TOOLS—Concluded

Wall ties, Morse	Whistle, steam
Wall irons	Wheelbarrows, wood
Water barrels	“ iron
Waterproofing	“ 2 wheeled for
Wedges, other than for Shims	concrete
Wheels, sprocket	Wrench, monkey
Winches	“ hose
“ handles	“ Stilson
Wire cutters	“ socket
“ electric bell	“ spanner
	“ rock drill

TELEGRAMS

- 279 In sending a telegram to the New York Office or branch offices, never sign same "*Frank B. Gilbreth.*" *Always sign the name of the sender.*
- 280 The only time to sign "*Frank B. Gilbreth*" is when corresponding with sub-contractors or dealers, and then sign *Frank B. Gilbreth, By.....*
- 281 When sending a telegram, a copy of the original must be made on our regular yellow confirmation blank, mailing same to the party to whom the telegram is sent.

EXPENSE ACCOUNT

- 282 Each employee is to make out his own Expense Account.
- 283 All Expense Accounts to be *approved* by a second person.
- 284 All cash items to be entered in Cash Account book. Expense accounts to be attached as vouchers, when Cash Account sheet is sent in.

WHITE LIST CARDS

- 285 We wish to keep track of those workmen who work in our interests, and to let them know when we need men. Get the addresses of those men who work faithfully. Make out a white list card for each good man when discharged or laid off.
- 286 As any business grows, the employees lose their individuality with their employer. This is discouraging to a workman who desires to have his efforts appreciated. We have devised a "*white list*" card so that we may know what each foreman thinks of an employee.
- 287 We shall send, to men of good records, postal card notifications which will put them on solid footing with any of our foremen, whether the men are known to them or not. We believe that the best class of workmen will appreciate our efforts and co-operate with us in making this system a success.
- 288 Workmen who spend the least time talking with one another during working hours, will, if other qualifications are equal, receive preference when the work slacks down.
- 289 Men who present "*white list*" notification cards must be given preference by our foremen at all times.

290 At the completion of the job, the Superintendent and Timekeeper must go over the time sheets and make sure that the proper White List Cards have been made out.

WRITE LAST NAME FIRST	TRADE
WRITE ADDRESS ON BACK OF THIS CARD	
(CROSS OUT THE ANSWERS YOU DO NOT USE)	
NUMBER OF CONTRACT WHERE HE WORKED LAST	
HE IS A VERY PROFITABLE MAN AND SHOULD BE SENT FOR EVERY TIME WE NEED MEN OF HIS TRADE	
HE IS A FAIRLY PROFITABLE MAN	
I COULD NOT JUDGE HIS ABILITY	
I CONSIDER HIM A CLASS MAN	
CAUSE FOR HIS LEAVING US	
THE WORK HE IS MOST PROFITABLE ON IS	
THIS CARD WAS MADE OUT BY	
FORM 8-10/16/06 1000	

BILLS

- 291 All bills are to be rendered to job in triplicate.
- 292 When bills are received, check up and O. K. every copy, using rubber stamp for "Quantity Correct, Prices Correct and Extensions Correct." This stamp to be placed on the front of each copy in the lower left hand corner.
- 293 "Prices Correct, etc.," stamp on face of bill must be filled in.
- 294 Number each bill, beginning with No. 1.
- 295 The original copy of all bills after being O. K.'d by the timekeeper and entered on "M" sheet, must be sent to the Owner, attached to the yellow "M" sheet upon which they are entered.
- 296 The duplicate copy of all bills is to be sent to the Accounting Department attached to the white "M" sheet upon which it is entered.
- 297 The triplicate copies of bills are to be filed numerically in the file provided for same on the job.
- 298 All bills are to be entered on the "M" sheet in the order of their number, if possible.
- 299 Credit bills or corrections from material men must also be obtained in triplicate, and the originals

turned over to the Owner. These are also to be stamped, numbered and O. K.'d exactly as though they were charges. They must also be entered on separate "M" sheets, marked in large letters "Credit." Duplicate copy of credit vouchers must be sent to the *New York* Office, attached to the white "M" sheet, upon which they are entered.

300 Bills must be checked up promptly and the original copies turned over to the Owners as soon as possible, to enable them to take advantage of any discount.

301 It is absolutely necessary that the *New York* Office receive a copy of all bills, and therefore should the Owners buy any material direct, it will be necessary for the Timekeeper to secure duplicate copies of such bills, which must also be entered on "M" sheets.

302 When opening accounts with new dealers, direct them to send bills as nearly up-to-date as possible.

FREIGHT

303 When paying freight, get separate receipted bills for each charge.

304 Freight bills on material purchased F. O. B. the job, are to be turned over to the Owner without being entered on "M" sheets.

305 Freight charges for material purchased F. O. B. shipping point (chargeable against cost of Job) are to be entered on "M" sheets.

BRICKWORK

- 306 The most profitable and best bond in common brickwork is one course of Flemish headers and seven courses of stretchers, then another course of Flemish headers, etc.
- 307 Use this bond wherever possible, except in earthquake localities, in which case use full headers every sixth course and also metallic headers.
- 308 Each bricklayer is responsible for the plumb of the lead, ting, corner, or angle, on which he is set to work. He will not be excused by the customary statement that it is plumb from where he took it. Mistakes can thus be corrected before it is too late, and at small cost.
- 309 Foremen carpenters and foremen masons will be held jointly responsible for the plumb of window and door frames—not only that they are set plumb, but that they are maintained plumb, and that they have plenty of spreaders to keep them from being sprung by brickwork.
- 310 Every bricklayer is responsible for the plumb of window and door frames adjoining his work, and must notify foremen of mistakes while they can be rectified at small cost.

- 311 The bricklayer on the lead that hauls in the line is the *boss of the line and the wall*. To him the foreman must give sufficient information to enable him to come to the right height for projections, beams and openings. He is responsible for all levels, heights, and accuracy of ting on the wall.
- 312 The man on the ting, or man on the middle of the wall, must notify the man on the hauling end of the line when the line is laid out, if not already noticed by him.
- 313 The man on the leads must be specially directed to keep the line moving. The boss of the wall must call for the man on the other lead to put the line up promptly, and he must haul it in promptly. He is responsible for delays caused by other lead men not putting up line promptly. The money is made in brickwork by hauling the line promptly. It is seldom good practice to have the line slacked until the last brick is laid out.
- 314 The bricklayers on the lead must stop in the middle of laying a brick to attend to the line.
- 315 Lumpers who lay brick by the thousand give more attention to the line than to all other points combined.
- 316 In no other way can foremen and timekeepers save so much money for the firm as by watching the line and seeing that it is put up the instant that the line is laid out.
- 317 *The boss of the wall* must notify foremen if mortar is too fat, or too sandy, or if it is not right in any way.

- 318 Boss of the wall must notify foremen if stock is not coming fast enough.
- 319 Lay all brick with shove joints. Use the *Gilbreth Scaffolding* wherever possible, because it keeps the mason where it is easiest for him to lay with shove joints. Do not economize on mortar. Do not slush the middle of the wall, as it prevents the next course from properly pushing mortar between the bricks of the course below. Joints must be well filled without slushing, except in freezing weather.
- 320 Haul the line to the bottom of all projections and not to the top.
- 321 Fill end joints of outside 4" of all exposed walls full of mortar.
- 322 Except when prevented by certain qualities of mortar, the best results in jointing are obtained by not jointing too often: probably about once every staging high. The best practice is for the outside men to get on the inside scaffold and back up for another header, and not waste time jointing while the inside men are backing up. Boss of wall will say when to do jointing.
- 323 When walls near ground and floors are jointed, it must be done with a straight edge. There is absolutely no exception to this rule. Foremen must provide every mason with pieces of furring 8'—0" for this purpose.
- 324 We desire to maintain our present hard earned reputation for doing the best possible brickwork. The difference in cost between the best and the poor-

est workmanship on brickwork is a very small percentage of the entire cost of the contract.

- 325 A bricklayer's time costs too much to have him do any more measuring with a rule than is absolutely necessary. Foremen should give the bricklayers a piece of strapping (2"x1" planed on one side) just the right length, with the entire information marked clearly on it.
- 326 Foremen should order a few bundles of strapping with the first order for lumber.
- 327 Toothers and putlog holes must be filled full of mortar or else they will dry out a different color than the other mortar.
- 328 Take the greatest care to cover thoroughly with mortar every portion of structural steel work. This is often neglected on most important work. All structural work must first be freed from rust by wire brushes and scrapers, then painted, and then covered with mortar, or in time it will begin to rust, and after rust once begins in the wall it cannot be stopped. For further information on this subject see copy of "*Cement*," Vol. 3, No. 2. Any kind of mortar helps to preserve iron and steel, but Portland cement is best. We are ready to pay for the labor and mortar needed to cover completely and thoroughly all structural steel and iron.
- 329 Care must be taken when *wooden beams* are built into brickwork, that mortar does not touch the wood, as it is likely to cause dry rot. Any kind of mortar will cause deterioration of wood.

- 330 The most expensive bond and also the best is "*plumb bond*"—this can be done properly only by cutting notches in the edge of a piece of furring, holding the end of the stick to the jamb and marking the center of each vertical joint. Many old time bricklayers think the same result can be obtained by plumbing the joints with a plumb rule. This method not only takes too long, but is too inaccurate for our work.
- 331 Order wooden wedges at the mill for setting cut stone. Use only white pine wedges for this work.
- 332 Rake joints in stone work 1" deep, and draw wedges before mortar is set.

MORTAR

- 333 *Lime mortar* must be kept *wet* while slaking. In addition to water hose, supply a water barrel so that water can be dashed by the pailful upon any lime that is crumbling or burning. Lime loses strength if allowed to "*burn*."
- 334 The *making of lime mortar* must commence early enough to have it at least two weeks old before using. This rule must be followed notwithstanding the fact that the making up of considerable quantities of mortar ahead of time is expensive, because of the extra handling and the greater labor of tempering up. The older the lime mortar, the better the work.
- 335 *Lime mortar* must be tempered until all the white spots in it disappear; otherwise these spots would swell and break the initial set of the mortar after the bricks are laid.
- 336 *Cement* must not be added to slaking lime mortar. Cement must be thoroughly *mixed dry* with sand before it is added to lime mortar, and just before it is to be used.
- 337 *Cement mortar* must be used as soon as mixed, unless *fat mortar* is more desired than strength.

- 338 The theory most widely accepted among cement experts is that cement, in setting, forms microscopic interlocking crystals. These crystals if broken while forming will never properly reunite. Therefore, cement, whether in mortar or concrete, should never be disturbed after it has once begun to set.
- 339 Give mortar men, or other men most faithful to our interests, first chance on all overtime work, tempering tubs, etc.
- 340 More bad results to cement in mortar and concrete are caused by *drying out too quick* than from any other cause. Any cement dealer or cement chemist can cite hundreds of cases of unsatisfactory work from these causes. Therefore, wet your forms thoroughly or else grease them so that they will not soak the water from the concrete. Wet the ground thoroughly before laying concrete, and do not allow so much as a dry plank to lay on it for at least two weeks after the work is finished.

OILING DOWN

- 341 When outside walls are oiled, great precaution must be taken that the stone in the wall does not receive the slightest spot. Oil will discolor stone and the stain cannot be removed. Raw linseed oil should be used, *never* boiled linseed oil.
- 342 Washing down brick walls with acid must be done with the greatest care. First, spray the wall thoroughly with water, so that brickwork will soak up as much water as possible. When the acid is applied, use as little as you can; it will then do its work on the face of the wall only, and not soak in and afterward appear on the face of the dry wall in the form of white spots, nor ruin the mortar in the joints. This method will not only do better work, but will save a large quantity of acid. Keep ropes away from acid or acid fumes, as a few drops of the acid would ruin their strength. Keep falls out from under staging when washing down, or they will get injured by the acid and workmen may get hurt.
- 343 Wash mortar from cut stone before it sets too hard.

SCAFFOLD

- 344 Have all *stagings* inspected by an intelligent bricklayer before they are used, and have him say in the presence of witnesses that the staging is right, before the same is used. We shall then know that we have done everything in our power to make the stagings secure and to prevent accident.
- 345 There are three ways of building outriggers for outside masons staging:—
- 1—Lash around the outrigger and the floor beam below with $\frac{1}{2}$ " rope; turn up with twister and nail the twister to the outrigger.
 - 2—Put eyebolts through the floor and lash in the same manner.
 - 3—Spike a piece of 3"x4" to the floor with plenty of big spikes and nail two pieces of board, each at least 1"x6", to the outrigger and to the spiking piece. This is the cheapest method and generally the best.
- 346 Use the *Gilbreth Scaffold* wherever possible, because it promotes good work as well as economy. Use it in preference to any other form of scaffold on over-hand brickwork, because it enables the bricklayers to back up the wall solid, every header high,

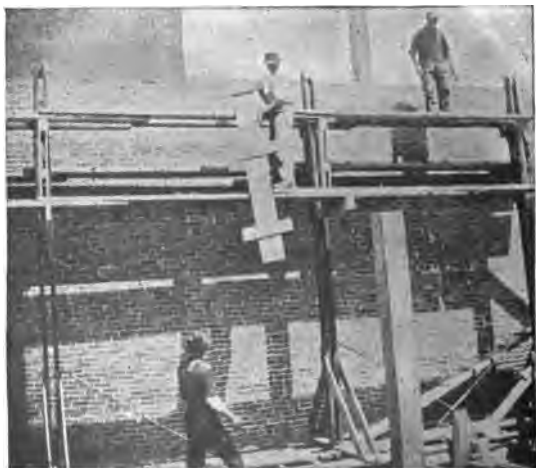
instead of building the over-hand face as thin as possible staging-high and then backing up.

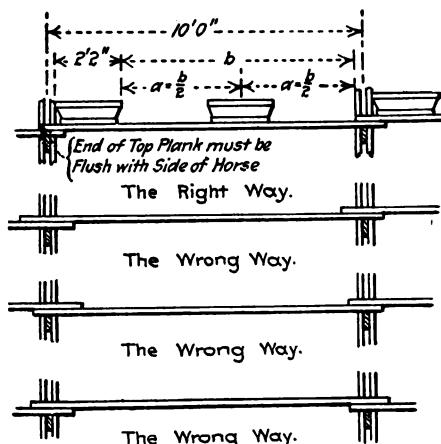
347 Where great speed of construction is required, build staging on both sides of the wall.

348 When two kinds of mortar are used on the *Gilbreth Scaffold*, put a temporary partition in the mortar box, as shown in pictures 298-25 and 298-12, pages 101 and 107.

349 The middle plank, or "center board," in the stock platform, should be 2"x10" and 8' to 9' long, with three boards 1"x8" and 1' 10" long nailed on securely. It is not necessary to have the "center board" the exact length between horses, as one end can be covered by a mortar box. These boards should be kept in stock and always used with the scaffold.

350 The most convenient length for plank for the *Gilbreth Scaffold* is 12 to 14 feet.





The **RIGHT** and the **WRONG** way to arrange plank and mortar boxes on the Gilbreth Scaffold



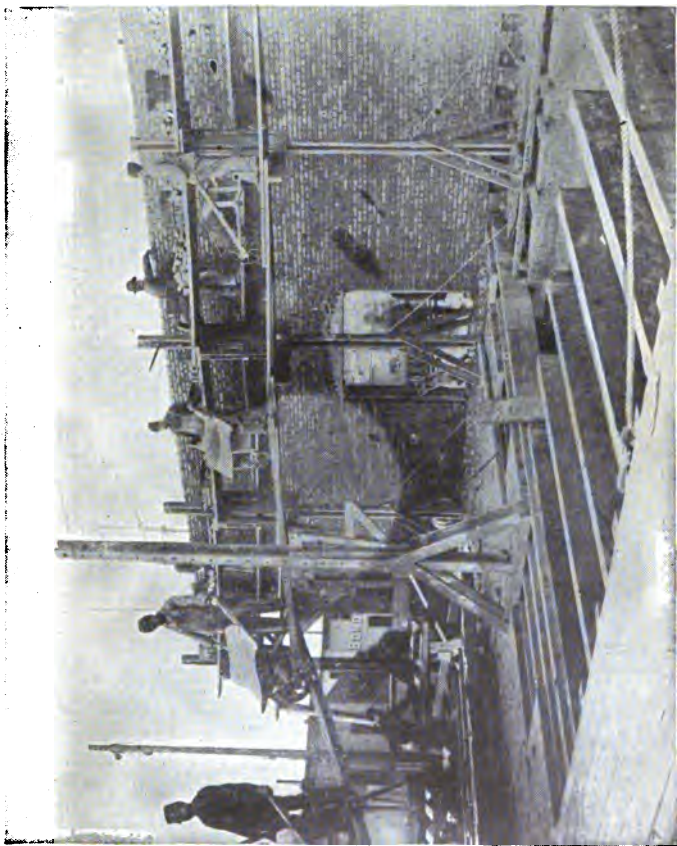
Photograph 298-25

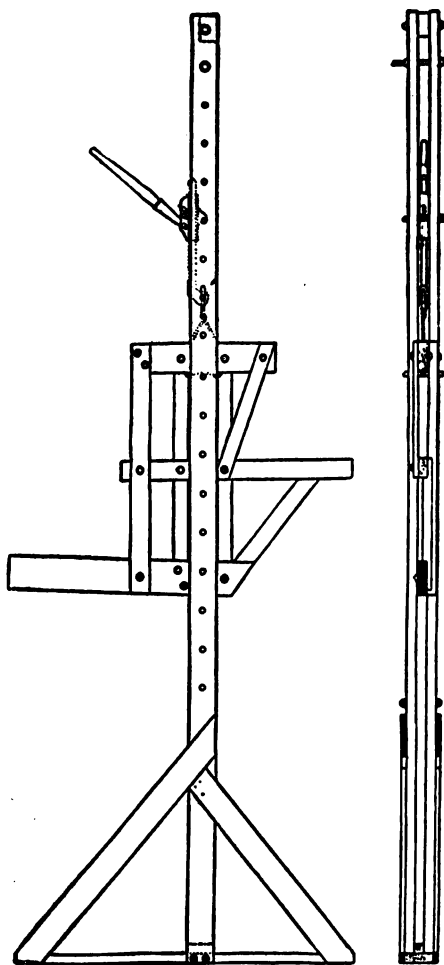
SYSTEM FOR SETTING UP THE GILBRETH SCAFFOLD

- 351 A—Do not build wall more than 3' 8" above floor before setting up scaffold.
 B—Put *red* side of horses against *brick* wall.
 C—Place horses 10' 0" apart.
 D—Hook one end of stay rod to eye bolt in horse and nail other end of stay rod to floor.
 E—Use no planks less than 2"x10".
 F—Make *bricklayers'* platform *two* planks wide.
 G—Make *tenders'* platform *two* planks wide.
 H—Make *stock* platform *three* planks wide.
 I—The plank on the stock platform should rest on only two horses, never on three horses.
- 352 J—Mortar boxes *never* over 4' 0" apart.
 K—Never jack stock platform higher than the inside 4" of wall.
 L—Keep ratchet and bearings of jack well greased. These jacks will wear out in one day unless thoroughly greased. It has always been difficult to get foremen to use enough grease on these jacks.

It has been demonstrated, beyond the possibility of a doubt, that if the Gilbreth Staging is set up and

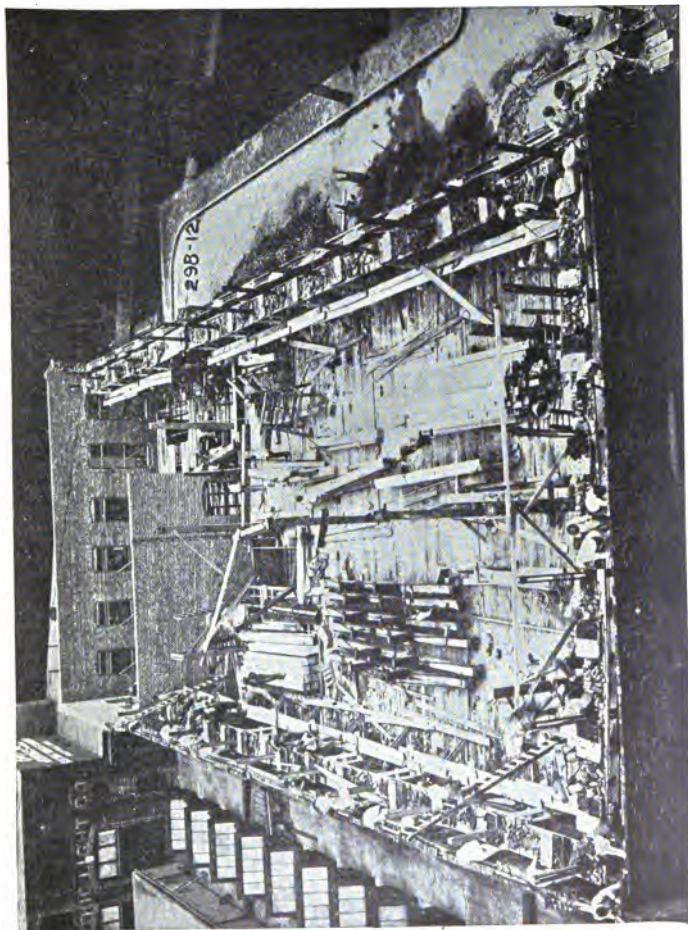
jacked up in accordance with the above rules, it will cause an average saving of \$1.00 per mason per day.



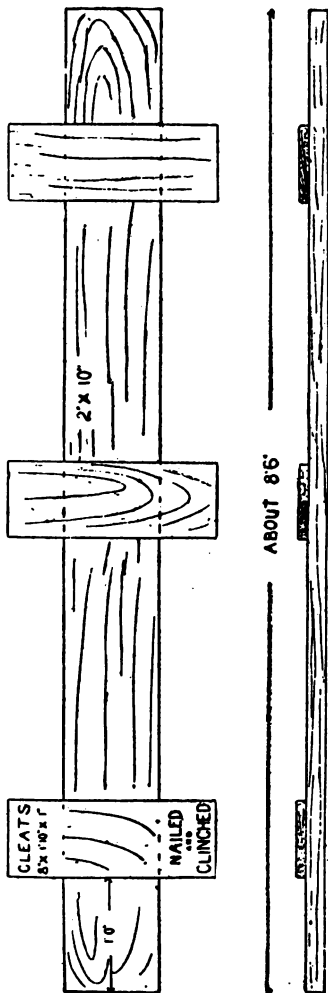


SYSTEM FOR TAKING DOWN GILBRETH SCAFFOLD HORSES

- 353 Take down planks, one at a time. Pull stay rods up from floor and unhook them. Lay each horse down on the floor, then slide frames down to the foot of the horses. Lowering frames in the horses, while horses are standing, will break the foot pieces of the horses.



Photograph 298-12



MAKE THE "CENTER BOARD" FOR GILBRETH SCAFFOLD EXACTLY AS SHOWN ABOVE

354 On work where the greatest speed of construction is demanded, set up the Gilbert Scaffold on both sides of the wall. This will enable you to build any wall a story high in half a day. This picture shows walls staged both sides on Lowell Laboratory of Electrical Engineering, Massachusetts Institute of Technology, built in 2 months and 17 days.



TALL CHIMNEYS

- 355 The best results in round chimneys are obtained by having no brick headers below the head of the chimney. Get permission from the Engineer or Architect to use galvanized wire cloth ties instead of brick headers for bonding the outside 4". This will permit backing up full width of wall at once.
- 356 The shell of a chimney must not be built into or touch the core, for the expansion of the core would crack and distort the shell. Not less than 1" play must be left at all points. Too much play between shell and core is better than too little.
- 357 If the plans show the shell and the core connected in any way except at the bottom, *stop* the work.
- 358 Plumb chimneys every 5' 0" in height with a mercury plumb bob.
- 359 Examine the mortar of the inside 4" of the chimney from top to bottom every two days, to see that it is setting fast enough to carry the work being built above it.
- 360 Do not economize on mortar. Lay all brick with a shove joint.
- 361 The temporary hole left for carrying stock to the elevator inside of the chimney must be located directly

under the hole for the smoke flue, or else directly opposite (half way around the chimney) the smoke flue. Get permission from the engineer to locate the cleanout door within the limits of this temporary hole.

362 Build the stock railway so that it pitches down toward the chimney. This will give speed in loading the elevator, for the cars will go down hill when loaded and up hill when empty.

363 Build a cover 7' 0" from the ground to protect the men loading the elevator. This cover should be



Photograph 300-34

at least 2" thick, and should cover all the inside of the chimney except the size of the car.

- 364 Build an automatic lid, strong enough for tenders to stand upon, to cover the elevator well at the top.
- 365 Build an outside protection over men at the bottom of the chimney. Make this strong enough to stop a brick falling from the top of the chimney.
- 366 Build a peach basket form on the top of the chimney, so that the head can be built perfect in shape.
- 367 Get permission to build a collar under the head of the chimney, to support the "peach basket."
- 368 Find out from the makers of the iron cap if some representative of our firm has seen the complete cap set up and all bolted together. This may cost some money, but it is in the interests of good work.
- 369 Each piece or section of the iron cap must be self supporting on the wall. If it is not shown thus on the plans, notify the office immediately.
- 370 Have the cap drilled and tapped with standard thread before leaving the shop, to support the attaching device for the lightning rod.

**TALLEST CHIMNEY
IN GREATER BOSTON**

HEIGHT 255 FEET

NOTE "PEACH BASKET"

LAST HUNDRED FEET BUILT IN 14 DAYS



CONCRETE

- 371 Concrete should be mixed as wet as possible without having any free water to wash the cement off the stone. Any man who advocates using concrete dryer than this has not kept up with the advances of engineering knowledge in the last few years. If, however, your Inspector requires dry concrete, give him what he wants.
- 372 *Ram all concrete*, its strength is increased nearly 50 per cent by thorough ramming. Do not attempt to ram concrete under water; the cement will be washed off the sand and stone.
- 373 In hot weather care must be taken to prevent concrete from drying too rapidly. Protect it from the sun, and, after the first 24 hours, keep it as wet as possible. Portland cement requires a large amount of water to form its crystals. You can't keep it too wet, the more water the better.
- 374 *Sand for concrete* must be coarse, clean and sharp. If such sand is not obtainable the job must be stopped. Fine sand must not be used for concrete even if it gives good results, unless there is coarse sand mixed with it.

- 375 The better the sand is graded the less superficial area, and, therefore, the better it will be coated, and the stronger the concrete it will make with a given quantity of cement.
- 376 On all masonry and concrete work use the exact quantity of cement called for in the specifications, and notify the Office if you do not think the proportions strong enough.
- 377 Use telegraph wire for braces where needed.
- 378 Pile cement in the storehouse so that the oldest will come out first.
- 379 The coefficient of expansion of concrete (1-2-4) has been determined as .0000055 for one degree F. This is nearly the same as the coefficient of untempered steel, which is .0000060.
- 380 The compressive strength of concrete is from 8 to 12 times the tensile strength.
- 381 The services of the Civil, Mechanical and Concrete Engineers of our Office force are at the command of Superintendents, Foremen and Timekeepers, to assist in designing and arranging set-ups especially adapted to the conditions of each particular job.
- 382 Our main office has on file drawings and installations that we have designed and erected in all parts of the world, some of which are measuring, feeding and mixing concrete for less than one cent per cubic yard.
- 383 Keep *concrete mixers* in perfect repair at all times by ordering duplicate parts from the United Concrete Machinery Company. All parts are made

to patterns, and are interchangeable with each other in like models. A stock is kept on hand and can be shipped on receipt of order. In ordering parts, give serial number of mixer, to be found on name-plate.

384 Our main office has access to all drawings made by the United Concrete Machinery Co., makers of concrete machinery.

385 Whenever cement is being used in car-load lots, a sample of at least ten lbs. is to be taken from each car, sealed, and carefully labelled with the date and car number. These samples to be kept in a dry place until the cement in that particular car has been used and the concrete is in place and thoroughly set.

385½ For further rules on concrete consult the Office.

386 The following tables will be of use in estimating the amounts of sand, cement, broken stone and gravel required, when the quantity of concrete is known.

CONCRETE WITH STONE DUST FOR ARTIFICIAL STONE					
Proportions of Mixture			Required for 1 cu. yd.		
Cement	Sand	Stone	Cement Bbls.	Sand cu. yd.	Stone cu. yd.
1	1.0	2.0	2.51	0.38	0.76
1	1.0	2.5	2.27	0.35	0.86
1	1.5	2.5	2.00	0.46	0.76
1	1.5	3.0	1.83	0.42	0.84
1	2.0	3.0	1.65	0.50	0.75
1	2.0	4.0	1.44	0.44	0.88
1	2.5	4.0	1.33	0.50	0.81
1	2.5	5.0	1.18	0.45	0.90
1	3.0	4.0	1.23	0.56	0.75
1	3.0	5.0	1.10	0.50	0.84

CONCRETE WITH "HAZELNUT" STONE						CONCRETE WITH STONE 2 1/2" AND UNDER					
Proportions of Mixture			Req'd for 1 c. yd.			Proportions of Mixture			Req'd for 1 c. yd.		
Cem ent	Sand	Stone	Cem- ent Bbls.	Sand c.yds.	Stone c.yds.	Cem- ent	Sand	Stone	Cem- ent Bbls.	Sand c.yds.	Stone c.yds.
1	1	2.0	2.57	0.39	0.78	1	1	2.0	2.63	0.40	0.80
1	1	2.5	2.29	0.35	0.70	1	1	2.5	2.34	0.36	0.89
1	1	3.0	2.06	0.31	0.94	1	1	3.0	2.10	0.32	0.96
1	1	3.5	1.84	0.28	0.98	1	1	3.5	1.88	0.29	1.00
1	1.5	2.5	2.05	0.47	0.78	1	1.5	2.5	2.09	0.48	0.80
1	1.5	3.0	1.85	0.42	0.84	1	1.5	3.0	1.90	0.43	0.87
1	1.5	3.5	1.72	0.39	0.91	1	1.5	3.5	1.74	0.40	0.93
1	1.5	4.0	1.57	0.36	0.96	1	1.5	4.0	1.61	0.37	0.98
1	1.5	4.5	1.43	0.33	0.98	1	1.5	4.5	1.46	0.33	1.00
1	2.0	3.0	1.70	0.52	0.77	1	2.0	3.0	1.73	0.53	0.79
1	2.0	3.5	1.57	0.48	0.83	1	2.0	3.5	1.61	0.49	.85
1	2.0	4.0	1.46	0.44	0.89	1	2.0	4.0	1.48	0.45	0.90
1	2.0	4.5	1.36	0.42	0.93	1	2.0	4.5	1.38	0.42	0.95
1	2.0	5.0	1.27	0.39	0.97	1	2.0	5.0	1.29	0.39	0.98
1	2.5	3.5	1.45	0.55	0.77	1	2.5	3.5	1.48	0.56	0.79
1	2.5	4.0	1.35	0.52	0.82	1	2.5	4.0	1.38	0.53	0.84
1	2.5	4.5	1.27	0.48	0.87	1	2.5	4.5	1.29	0.49	0.88
1	2.5	5.0	1.19	0.46	0.91	1	2.5	5.0	1.21	0.46	0.92
1	2.5	5.5	1.13	0.43	0.94	1	2.5	5.5	1.15	0.44	0.96
1	2.5	6.0	1.07	0.41	0.97	1	2.5	6.0	1.07	0.41	0.98
1	3.0	4.0	1.26	0.58	0.77	1	3.0	4.0	1.28	0.58	0.78
1	3.0	4.5	1.18	0.54	0.81	1	3.0	4.5	1.20	0.55	0.82
1	3.0	5.0	1.11	0.51	0.85	1	3.0	5.0	1.14	0.52	0.87
1	3.0	5.5	1.06	0.48	0.89	1	3.0	5.5	1.07	0.49	0.90
1	3.0	6.0	1.01	0.46	0.92	1	3.0	6.0	1.02	0.47	0.93
1	3.0	6.5	0.96	0.44	0.95	1	3.0	6.5	0.98	0.44	0.96
1	3.0	7.0	0.91	0.42	0.97	1	3.0	7.0	0.92	0.42	0.98
1	3.5	5.0	1.05	0.56	0.80	1	3.5	5.0	1.07	0.57	0.82
1	3.5	5.5	1.00	0.53	0.84	1	3.5	5.5	1.02	0.54	0.85
1	3.5	6.0	0.95	0.50	0.87	1	3.5	6.0	0.97	0.51	0.89
1	3.5	6.5	0.92	0.49	0.91	1	3.5	6.5	0.93	0.49	0.92
1	3.5	7.0	0.87	0.47	0.93	1	3.5	7.0	0.89	0.47	0.95
1	3.5	7.5	0.84	0.45	0.96	1	3.5	7.5	0.86	0.45	0.98
1	3.5	8.0	0.80	0.42	0.97	.....	.....	.....	.....	.....	.....
1	4.0	6.0	0.90	0.55	0.82	1	4.0	6.0	0.92	0.56	0.84
1	4.0	6.5	0.87	0.53	0.85	1	4.0	6.5	0.88	0.53	0.87
1	4.0	7.0	0.83	0.51	0.89	1	4.0	7.0	0.84	0.51	0.90
1	4.0	7.5	0.80	0.49	0.91	1	4.0	7.5	0.81	0.50	0.93
1	4.0	8.0	0.77	0.47	0.93	1	4.0	8.0	0.78	0.48	0.95
1	4.0	8.5	0.74	0.45	0.95	1	4.0	8.5	0.76	0.46	0.98
1	4.0	9.0	0.71	0.43	0.97	.....	.....	.....	.....	.....	.....
1	5.0	9.0	0.66	0.50	0.90	1	5.0	9.0	0.67	0.52	0.93
1	5.0	10.0	0.62	0.47	0.95	1	5.0	10.0	0.63	0.48	0.96
1	6.0	11.0	0.55	0.51	0.93	1	6.0	11.0	0.56	0.52	0.94
1	6.0	12.0	0.52	0.48	0.95	1	6.0	12.0	0.54	0.49	0.98
1	7.0	13.0	0.47	0.50	0.93	1	7.0	13.0	0.48	0.51	0.95
1	7.0	14.0	0.45	0.48	0.96	1	7.0	14.0	0.46	0.49	0.92

CONCRETE WITH 2½ INCH STONE.						CONCRETE WITH GRAVEL ¾ INCH AND UNDER					
Proportion of Mixture			Req'd for 1 c.yd.			Proportions of Mixture			Req'd for 1 c. yd.		
Cem-ent	Sand	Stone	Cem-ent Bbls.	Sand. c.yds.	Stone c.yds.	Cem-ent	Sand	Grav-vel	Cem-ent Bbls.	Sand. c.yds.	Gr'vel c. yds.
1	1	2.0	2.72	0.41	0.83	1	1	2.5	2.10	0.32	0.80
1	1	2.5	2.41	0.37	0.92	1	1	3.0	1.89	0.29	0.86
1	1	3.0	2.16	0.33	0.98	1	1	3.5	1.71	0.26	0.91
.....	.....	.....	.....	.....	.....	1	1	4.0	1.55	0.24	0.94
1	1.5	2.5	2.16	0.49	0.82	1	1.5	3.0	1.71	0.39	0.78
1	1.5	3.0	1.96	0.45	0.89	1	1.5	3.5	1.57	0.36	0.83
1	1.5	3.5	1.79	0.41	0.96	1	1.5	4.0	1.46	0.33	0.88
1	1.5	4.0	1.64	0.38	1.00	1	1.5	4.5	1.34	0.31	0.91
.....	.....	.....	.....	.....	.....	1	1.5	5.0	1.24	0.28	0.94
1	2.0	3.0	1.78	0.54	0.81	1	2.0	3.5	1.44	0.44	0.77
1	2.0	3.5	1.66	0.50	0.88	1	2.0	4.0	1.34	0.41	0.81
1	2.0	4.0	1.53	0.47	0.93	1	2.0	4.5	1.26	0.38	0.86
1	2.0	4.5	1.43	0.43	0.98	1	2.0	5.0	1.17	0.36	0.89
.....	.....	.....	.....	.....	.....	1	2.0	6.0	1.03	0.31	0.94
1	2.5	3.5	1.51	0.58	0.81	1	2.5	4.0	1.24	0.47	0.75
1	2.5	4.0	1.42	0.54	0.87	1	2.5	4.5	1.16	0.44	0.80
1	2.5	4.5	1.33	0.51	0.91	1	2.5	5.0	1.10	0.42	0.83
1	2.5	5.0	1.26	0.48	0.96	1	2.5	5.5	1.03	0.39	0.86
1	2.5	5.5	1.18	0.44	0.99	1	2.5	6.0	0.98	0.37	0.89
.....	.....	.....	.....	.....	.....	1	2.5	7.0	0.88	0.33	0.93
1	3.0	4.0	1.32	0.60	0.80	1	3.0	5.0	1.03	0.47	0.78
1	3.0	4.5	1.24	0.57	0.85	1	3.0	5.5	0.97	0.44	0.81
1	3.0	5.0	1.17	0.54	0.89	1	3.0	6.0	0.92	0.42	0.84
1	3.0	5.5	1.11	0.51	0.93	1	3.0	6.5	0.88	0.40	0.87
1	3.0	6.0	1.06	0.48	0.97	1	3.0	7.0	0.84	0.38	0.89
.....	.....	.....	.....	.....	.....	1	3.0	7.5	0.80	0.37	0.91
1	3.5	5.0	1.11	0.59	0.85	1	3.0	8.0	0.76	0.35	0.93
1	3.5	5.5	1.06	0.56	0.89	1	3.5	6.0	0.88	0.46	0.80
1	3.5	6.0	1.00	0.53	0.92	1	3.5	6.5	0.83	0.44	0.82
1	3.5	6.5	0.96	0.51	0.95	1	3.5	7.0	0.80	0.43	0.85
1	3.5	7.0	0.91	0.49	0.98	1	3.5	7.5	0.76	0.41	0.87
.....	.....	.....	.....	.....	.....	1	3.5	8.0	0.73	0.39	0.89
1	4.0	6.0	0.95	0.58	0.87	1	3.5	8.5	0.71	0.38	0.91
1	4.0	6.5	0.91	0.55	0.90	1	3.5	9.0	0.68	0.36	0.92
1	4.0	7.0	0.87	0.53	0.93	1	4.0	7.0	0.77	0.47	0.81
1	4.0	7.5	0.84	0.51	0.96	1	4.0	7.5	0.73	0.44	0.83
1	4.0	8.0	0.81	0.49	0.98	1	4.0	8.0	0.71	0.43	0.86
.....	.....	.....	.....	.....	.....	1	4.0	8.5	0.68	0.42	0.88
1	5.5	8.0	0.74	0.57	0.91	1	4.0	9.0	0.65	0.40	0.89
1	5.0	9.0	0.70	0.53	0.96	1	4.0	9.5	0.63	0.38	0.91
.....	.....	.....	.....	.....	.....	1	4.0	10.0	0.61	0.37	0.93
1	6.0	9.0	0.65	0.59	0.89	1	5.0	10.0	0.57	0.43	0.87
1	6.0	10.0	0.62	0.56	0.93	1	5.0	12.0	0.51	0.38	0.92
.....
1	7.0	11.0	0.54	0.51	0.91	1	6.0	12.0	0.48	0.44	0.88
1	7.0	12.0	0.52	0.55	0.95	1	6.0	14.0	0.43	0.40	0.92
.....
1	7.0	11.0	0.54	0.51	0.91	1	7.0	14.0	0.42	0.44	0.88
1	7.0	12.0	0.52	0.55	0.95	1	7.0	16.0	0.38	0.40	0.92

DUTIES OF ENGINEERS AND RIGGERS

- 387 Engines must be kept so that they run without noise, except the noise from the gears.
- 388 If an unusual sound is heard from any piece of machinery, stop it at once and ascertain the cause. Many bad accidents may be avoided by strict observance of this rule.
- 389 Engines must be kept in thorough repair at all times.
- 390 *Always* keep engines housed.
- 391 When a derrick is not in use, put the dog on the boom drum of the engine so that boys cannot drop the boom and cause damage.
- 392 When engine on double elevator is idle, keep friction down hard and drop in the dogs, or there will be accidents caused by men getting on the upper car before the engineer is ready.
- 393 Never allow the friction clutches of an engine to get wet. Never leave the levers down over night.
- 394 When leaving derrick for the night, either drop the boom to the ground or take a strain on something so that the wind cannot blow the boom around against wires or Railroad tracks.

- 395 When an engine is to remain out of use for a few days, place a nail keg or a board over the smoke stack to prevent water from rusting out the tubes.
- 396 During wet weather daub the bright parts of your engine with gudgeon grease.
- 397 When starting an engine in cold weather, limber it up before placing any load upon it, by opening the drip cocks and the cocks on the steam chest and letting steam blow through for a few minutes before opening the throttle enough to start the engine. When the engine is first started run it very slowly, leaving all cocks open. Many cylinders are cracked by a sudden change of temperature.
- 398 The head rigger is responsible for the condition of all engines and engine houses. He is to take packing out of engines when they are not in use. He is to keep engine houses in perfect repair at all times. He must see that all engines are kept in condition for the greatest possible speed.
- 399 Oil all derricks, elevators and wire ropes daily. Keep on hand cheap black grease (3 cts. per lb.) for wire ropes. These ropes will last three times as long if greased and kept out of grit and dirt. A wire rope is not properly greased if you can see individual wires.
- 400 Lay down permanent logs and joists to keep falls between derricks and engines at least 6" above the ground.
- 401 When a mast and boom are not in use, see that they are laid flat and supported in at least three places. This will prevent warping and twisting.

- 402 Inspect frequently all guy clamps, guy posts and guys in windows to see that they have not been tampered with.
- 403 Give preference to the engineer who keeps his engine in the best condition.
- 404 Make engineer, when employed, sign a receipt for the tools in the engineer's chest.
- 405 Have all engine and elevator bells in duplicate to avoid delay from breakdowns.
- 406 Engineers should apply to Superintendent for worn shovels to be used in firing.
- 407 Cover engine water barrels completely, except where suction hose enters.
- 408 Keep this barrel clean and free from oil so that the boiler will not foam or get a sediment. Never allow anyone to wash his hands in this barrel.
- 409 Two men are usually enough to move an engine. First pry or jack up the front and back and place rollers under the skids, then take a hitch around a tree, post or a "dead man" and let the engine use its own steam to pull itself along.
- 410 An engine with two snatch blocks can help a team out of almost any difficulty.
- 411 Keep water in the ash box of the boiler at all times, and keep the ash box well cleaned out. This will prevent burning out grates and will give better draft.
- 412 A thin, clean fire will give 100% more heat than a thick one, because a thick fire chokes the tubes

and combustion takes place not in the tubes but in the bonnet.

- 413 Blow off the water glass several times a day and never depend upon it. The water cocks are put there to use and are the only sure way of ascertaining the water level.
- 414 *Notes on Boiler Scale*:—Many boiler explosions are caused by the weakening of the iron from strain due to unequal expansion. This is caused by scale on the heating surface. An accumulation of scale $\frac{1}{32}$ " thick requires 10% more fuel; $\frac{1}{16}$ " of scale requires 20% more; $\frac{1}{8}$ " of scale requires 30% more; and $\frac{1}{4}$ " requires 60% more. By keeping the boilers clean, considerable fuel is saved.
- 415 *Boiler Tool Chest*—Tool chests which go with boilers are to contain spare sheet packing, three spare gauge glasses of proper size and length, in addition to all necessary tools.
- 416 Remove the clinkers from the boiler frequently.

ROCK DRILLS

SHIPPING TO JOB

- 417 When shipping rock drills to or from the C. M. R. & T. Co., see that the following parts are present:

Cylinder complete	100 feet steam hose
Tripod	Couplings
Saddle	Drills
Three Weights	Wrenches and tools
Weight Hangers	Blacksmith's sharpening
Leg points, clamps and	tools
set screws	Oil cups

- 418 The cylinder and all small parts and fittings not attached to tripod shall be boxed.

SETTING UP

- 419 When drill is set up, see that the cylinder is firmly bolted to saddle. Carefully adjust tripod and bed points firmly by pointing a place in rock where each leg is to set. In case one of the points rests on a soft spot, put a common iron washer on the leg point and set the latter on a piece of plank.
- 420 See that all the nuts, bolts, and adjustments work easily and are well oiled. Put oil on the threads of both nuts and bolts.

- 421 Before connecting on the steam or compressed air pipe, blow it out for a short time to clear it of dirt, moisture, rust, scale, etc., which are very undesirable in the valves and cylinder of the machine.
- 422 See that the cylinder lubricator is in place and in working order.

OPERATING

- 423 Having set the drill up over the proper spot, draw the piston down until it strikes the bottom end of cylinder; run the feed down until it strikes the rock; then give the feed one more turn to allow clearance between the bottom end of cylinder and the piston.
- 424 Close the throttle and connect on the steam or air, after blowing out pipe. Clear out the water of condensation before starting to run drill. This may be done by loosening up cylinder heads and working the piston up and down by hand until free from water, and well warmed up.
- 425 Tighten up heads and start slowly until hole is about six inches deep, then open up the throttle valve wide and allow the machine to acquire full speed. Keep holes about half full of water, which will keep rock dust from clogging drill.
- 426 When hole is to be entered on a slanting face of rock, spot a square place on which to start drill and avoid breaking the tool.
- 427 When placing drill in chuck, see that it is entered full distance. Wipe the mud, dirt and oil from off the shank before placing in chuck.

428 When the drill becomes stuck in the hole and will not work, loosen up chuck and back it away from the drill. When drill shank is free from chuck, see if drill and piston are in line. If not, the cylinder must be moved to line with drill or an attempt made to straighten hole.

429 When hole begins to run out, if noted in time, it can usually be made straight by running slowly with short strokes. Where other methods fail, drill may often be kept in line by throwing small pieces of cast iron in bottom of hole.

430 Set up all the bolts and nuts occasionally.

431 Do not use a sledge on your drill. It is made to deliver a blow, not to receive it. Make all adjustments with proper wrenches, and if necessary to strike a drill with a hammer, use hand hammer and use it carefully.

432 The drills or bits used with the machine are made in sets, each containing several lengths. Commonly the number of drills per set is something less than one per foot of the rated capacity of the machine, that is:

Drills working to depth of	5ft.	5 drills per set.
Drills working to depth of	8ft.	6 drills per set.
Drills working to depth of	12ft.	8 drills per set.
Drills working to depth of	20ft.	10 drills per set.

433 There should be at least two sets of drills with each machine, one of which is being sharpened while the other is in use, as the apparatus is profitable only when running.

- 434 When the hole is started, use the shortest drill. This is followed by the next size, until the full capacity of the drill is reached.
- 435 Feed drill fast enough to give it full strokes. Too slow feed allows cylinder to strike lower cylinder head; too fast feed shortens the stroke and does not get full capacity from the machine.
- 436 When starting run slowly to avoid making the hole three-cornered.
- 437 It goes without saying that a good blacksmith should always be on the job to keep drills sharp and in the best condition.

CARE OF DRILLS

- 438 When a new man is running drill it is better to have him run it slowly until he becomes accustomed to handling it. Have him use low pressure, about 30 pounds, until he has learned, when he may turn on full pressure—60 pounds.
- 439 Large machines should not be used for shallow holes in soft rock, when the principal item of cost is that of moving drill. A small machine is more economical.
- 440 Pistons should be well oiled with a good cylinder oil if using steam, or No. 1 engine oil if using air.
- 441 The stuffing box on lower head is a great factor in economical running. If it be too tight it will cause drill to run hard and with less capacity. If too loose, it will cause leakage of steam. Keep it as near right as possible, rather loose than tight.

- 442 Feed cylinder with plenty of oil, as most new drills give trouble from lack of proper lubrication.
- 443 In cold weather see that the machine is left with no water in the cylinder or passages.
- 444 Practically all makes of rock drills work equally well with steam or compressed air, although some slight changes are made for drills intended solely for air.
- 445 Have an ample length of hose for each drill, at least fifty feet; a hundred feet is better, as it is not economical to pipe every shift of position.

PIPE, HOSE AND FITTINGS

- 446 The pipe should be amply large to carry steam or air for the proper number of drills. Keep it away from the ground as much as possible, and free from wasteful leaks. Give it a proper slant to one or more points where the water of condensation may be removed through drip valves.
- 447 Place a valve between pipe line and hose, that pressure may be removed from hose when drill is not working.
- 448 When inserting coupling in hose end, "soap" it so that it will not stick. More hose is ruined by carelessly inserting the couplings than in any other way. The best hose is five or six ply marline or steel wound. Hose is expensive and should be carefully used.
- 449 See that the rubber lining of the hose is not torn, for if torn the steam will get between the rubber

lining and the duck cover and spoil the pipe in a short time. Steam hose should last in good condition from six months to a year of constant use. Air hose should last three years, with constant use.

BITS

450 Bits for steam drills are generally of two kinds, determined by shape of cutting edge:

A. The cross **+** bit, which is most commonly used and preferred because of its regular shape, which makes it easier to sharpen.

B. The **×** bit, which is sometimes preferred to the other type. There are jobs on which the **×** bit can be used economically, but it is harder to sharpen on account of its shape, and for that reason is not so popular. However, this bit will make a round hole where the other will not, since the former never strikes twice alike.

451 When the cross **+** bit works badly it is heated and the adjacent corners bent toward each other until they take somewhat the shape of the **×** bit. This will often work better and is ample indication of the kind of bit needed.

DRILL HORSE-POWER REQUIRED

- 452 The boiler H. P. required for one of each of the following sizes of drills is as follows:

Diameter of Cylinder	Boiler Horse Power
2¼ inches	5
2¾ "	7
3¼ "	10
3¾ "	12
4½ "	15
5½ "	25

BLACKSMITHS' TOOLS

- 453 For making and repairing drill bits, the job should have the following tools for each blacksmith:

- 1 Dolly for ✕ drill
- 1 Dolly for + drill
- 1 top-splitting tool
- 1 bottom-splitting tool
- 1 set hammer
- 1 shank swage
- 1 sow

COSTS OF DRILLING

- 454 Drilling by hand 6200' of hole, cost per foot \$.086
 Drilling by steam 7500' of hole, cost per foot .058
 Drilling by compressed air, 10,000' of hole, cost per foot .043
 Including reaming for blasting.

HAND DRILLING

455 One man with churn drill, fair day's work, 10 hours, 1¾" hole:

From 7' to 8' of hole per day, through granite.

From 3' to 5' of hole per day, through solid quartz.

From 8' to 9' of hole per day, through limestone.

From 9' to 10' of hole per day, through sandstone.

STEAM ROCK DRILLING

456 One machine will drill hole 1" to 2" in diameter from 30' to 50' in depth in ten hours, depending on kind of rock. Bits require sharpening every third to fourth foot of depth, depending on the kind of rock. One blacksmith and helper can take care of five or six machines.

Limestone, steady work, 3" drill, 100' to 120' per day, 10 hours.

Sandstone, steady work, 3" drill, 100' to 500' per day, 10 hours.

Granite, steady work, 3½" drill, 70' to 100' per day, 10 hours.

Trap Rock, steady work, 3½" drill, 50' to 90' per day, 10 hours.

AIR COMPRESSORS

457 The care of the air compressors, their fittings and appurtenances, is to follow the same general rules that are given for other kinds of steam machinery.

458 In store sheds they should be kept with their tanks, piping, tool boxes and smaller parts in close vicinity, so that all may be quickly found, loaded and shipped.

459 In setting, compressors of whatever kinds should be given a heavy concrete foundation and anchored with the usual bolts.

460 A. There are in general two kinds of compressors in use—the direct connected compressor, and the belted or geared type. For small jobs the latter types are perhaps preferable, as they may be run from shaft line overhead.

B. For compressors of large capacity, direct connected Duplex machines give the most satisfaction.

C. The Duplex machine has the advantage of enabling the operator to take down one side for repairs while running the other, and if speed is increased, the full, or nearly full capacity of the machine may be attained with one side.

APPURTENANCES OF COMPRESSORS

- 461 Each compressor plant should have a tank, located within fifty feet of the compressor, of a capacity of from 50 to 100 feet, depending upon the capacity of plant.
- 462 The object of the tank is to act as a reservoir and maintain even pressure in pipe line. It forms a reserve space for air which may be needed for sudden calls on the plant. It serves as a condenser for the moisture in the warm compressed air, and thus keeps the pipe line dry.

COOLING WATER

- 463 Machines compressing air to over twenty-five pounds gauge pressure require cooling water. In such plants the air cylinders are provided with jackets or spaces through which water can circulate and carry away the heat of the compressed air in the cylinder. This is necessary, as the efficiency and capacity of the compressor depends largely on keeping the air cool.
- 464 The cooling water may be pumped through the water jacket or simply allowed to gravitate through from a tank or other means. Frequently, cooling water which has been passed through jacket and warmed is used for feeding boiler.

PIPING

- 465 In piping off compressor, it is a good plan to put end of suction pipe out of doors in a shady spot, as it will then draw cooler air. The air discharge pipe leads directly to the air tank, and it is advisable to put a three-way cock on close nipple at the end of pipe, close to tank. This enables engineer to start his compressor and run it, at times, without load, as he may open the three-way cock and discharge the pump into open air.

GOVERNOR, ETC.

- 466 For intermittent work, such as rock-drilling, etc., the compressor should have attached to it a form of governor called an "Unloading Device." This unloading device has the effect of taking the load off the machine when the tank is full of air at the pressure required, and little or none is being drawn off for a time. Such devices generally attain the desired result by throwing the discharge from one end of the cylinder into the other end, so that the piston simply passes it back and forth without compressing. Other devices act on the steam supply to the engine, throttling down when pressure is sufficient.
- 467 Where no unloading or throttling devices are used there is a constant blowing from the escape valve, and all of the excess of compressed air is a dead loss.

AIR VALVES

- 468 The kinds, size and number of valves in the compressor are points of vital importance to the life of the machine. They should be ample in size and number, easily accessible, and of some type, preferably metal, which will maintain a perfect seat. Leather valves are not good enough to hold hot air under high pressure. There are two types of valves in use, and both have their advantages. One is the mechanically controlled valve, like a slide valve or poppet of an engine. The other, the spring type pulsating valve, is probably the most popular, as it varies its pulsations with the amount of air passing through, and may be said to adjust itself to the load. It is very important that the air valves be located where they may be readily taken out, repaired and cleaned.
- 469 The best practice is to locate the valves in the cylinder heads of the compressor.

REHEATER

- 470 Where compressed air is carried to a distance in the pipes, it loses heat and contracts in so cooling. To prevent this loss of efficiency, it is common to introduce, in the line at the point where the air is to be used, a "reheater," which warms the air to the point where it was when it left the compressor. By this means, a matter of 30 per cent may be saved on large jobs.

CARE OF COMPRESSOR

- 471 Before starting to compress into the tank, blow out the cylinder ; get all free from dirt and grit.
- 472 For the air cylinder use good engine or machinery oil. Do not use cylinder oil in air cylinder, as it is too heavy.
- 473 For the steam end of compressor use cylinder oil as directed under "Cylinder Lubricators."
- 474 Keep the journals and brasses set up tightly enough to avoid pounding and knocking, but without heating.
- 475 See that there is no dirt or grit under air valves and listen for the wheezing sound peculiar to leaky air valves.
- 476 See that cooling water flows continuously and sufficiently.
- 477 Read over Engine Rules for care of steam end.

DATA

- 478 Where long length transmission pipes are used, air is more economical for drills than steam.
- 479 Compressed air can be carried for miles in pipes, while steam can be carried but a few hundred feet,

owing to condensation. Hose lasts longer with air than steam.

480 For figuring the amount of free air per drill, the table which follows gives the amount used by one drill only. For five drills the amount may be cut down 25 per cent; for ten drills, about 33 per cent; other numbers in proportion.

481 **CUBIC FEET OF FREE AIR REQUIRED TO RUN ONE DRILL
OF SIZE AND AT THE PRESSURE
STATED BELOW**

Gauge Pressure	Size and Cylinder Diameter of Drill in Inches													
	2	2¼	2½	2¾	3	3½	3¾	3½	3½	4¾	5	5½		
60	50	60	68	82	90	95	97	100	108	118	130	150	164	
70	56	68	77	93	102	108	110	113	124	129	147	170	181	
80	63	76	86	104	114	120	123	127	131	143	164	190	207	
90	70	84	95	115	126	133	136	141	152	159	182	210	230	
100	77	92	104	126	138	146	149	154	166	174	199	240	252	

CARE OF ENGINES

STEAM ENGINES

- 482 When an engine is sent to a job, the following fittings are to be sent with it:

Governor	Piston and Valve Packing
Governor Belt	Drip-cocks
Sight Feed Lubricator	Cotton Waste
Steam Pipe	Oil Can
Exhaust Pipe	Oil Feeder
Oil Cups for Bearings	Can of Cylinder Oil
Throttle Valve	Can of Lubricating Oil

All spanners and wrenches necessary.

- 483 Engines must be sent out with full complement of fittings packed in a suitable tool box, provided with padlock.
- 484 A blue print list of fittings shall be pasted in each box.
- 485 In running engine on the job, see that it is kept clean, well oiled, free from all pounding and knocks in the wrist pin, crank pin, main bearings or elsewhere. See that it runs cool, and keep brasses keyed just enough to avoid knocking without heating.
- 486 See that each oil cup is kept full of oil and is working properly.

487. Never start an engine with drip-cocks closed. Before starting an engine, whenever possible, blow steam through the cylinder to warm it and to clear it from water.
488. For cylinder oil, use heavy mineral oil known as "Cylinder Oil," and no other. For lubrication oil, use what is known as "Number One" Engine Oil.
489. Never use lard oil on machinery. Pure "Winter Strained" lard oil is unsurpassed as a lubricant when it is pure. It is very high-priced, however, when pure, and the common varieties whose prices are not prohibitive are full of acid used in the process of manufacture, and consequently very detrimental to machinery.

ADJUSTMENT TOOLS

490. Engineers are to use proper wrenches, spanners, etc., for adjusting parts of their engines. The use of cold chisels, hammers and other improvised wrenches, or adjusting tools is forbidden. If the tool box does not contain the proper tools, report the fact to the C. M. R. & T. Co.

CYLINDER LUBRICATORS

491. On every engine, without exception, shall be placed a sight feed cylinder lubricator, preferably of the Detroit Single Connection Type of the following sizes:

For engines up to 8x8, use a 1-3 pint sight feed lubricator.

For engines up to 10x10, use a $\frac{1}{2}$ pint sight feed lubricator.

For engines up to 10x18, use a 1 pint sight feed lubricator.

- 492 The engineer is to see that this lubricator is filled with oil and is feeding evenly. Put very little oil into the cylinder of the engine; two drops per minute is enough ordinarily. For bearing cups, use the sight feed, glass body variety.

COLD WEATHER

- 493 In cold or freezing weather, when engine is shut down for the night, drain all water and oil from the cylinder and lubricator.
- 494 When filling the cylinder lubricator, use the oil feeder provided. Cylinder oil is too expensive to waste by careless pouring from the can into the small opening of the lubricator.

VALVE SETTING

- 495 In case the engine valve on job gets out of order, it shall be the duty of the Engineer to set the valve as quickly as possible, without removing the valve chest cover, if possible during working hours, so that less time may be lost. If valve is thus set during working hours, it shall be verified after working

hours by the Engineer, who shall remove valve chest cover for that purpose.

For the guidance of the Superintendent and Foremen the following notes are given:

496 The symptoms of valve trouble show themselves first in unequal exhaust; that is, the engine exhausts (or puffs) on one side harder than on the other; it seems to run hard and to be unequal to the usual amount of work, and finally, when the valve is very far out, there are numerous dead points where it is found impossible to start the engine.

497 In setting valves, there are always two cases to be considered:

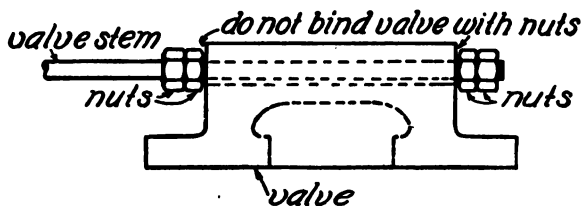
First: Where the eccentric cam is keyed to the shaft.

Second: Where the eccentric cam is set-screwed to the shaft.

498 The operation of setting a valve usually consists of two parts, viz: equalizing the valve travel, and adjusting the lead or valve opening.

499 The object of equalizing the valve travel is to make the lead or valve opening the same at both ends of the cylinder. The valve is held on the stem by double nuts on either end. (See Cut No. 1.) And at the time the engine leaves the shop they are supposed to be so set that, when the eccentric rotates around the shaft, the valve will move back and forth equal distances on either side of center line of valve seat. In the course of time the nuts become loosened or misplaced and the valve may travel very unequally,

opening, say, $\frac{1}{4}$ " on one end and not at all on the other. This, of course, cuts down the amount of steam on one end of the cylinder and increases the amount received on the other, tending to cut down power of engine, causing it to run one sided, or putting unequal strain on the parts.



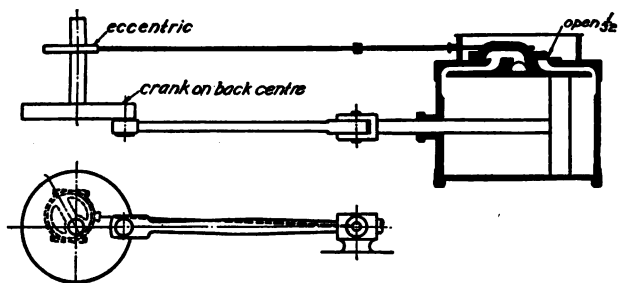
Cut No. 1

500 To equalize the valve travel, rotate the eccentric through 360 degrees on the shaft and see that the valve moves the same distance each side of center of valve seat. To do this, where the eccentric cam is keyed to the shaft, the whole combination of shaft, cam, crank, etc., must be rotated one turn. If, however, the cam is set-screwed on the shaft, the set-screws may be loosened and the cam alone moved. If valve travel is found to be unequal, adjust position of valve on stem by tightening nuts on the side where the excess of travel lies, and loosen up the other side. After one or two trials the exact position may be found.

501 To set a valve, i. e., to give it a proper lead, proceed as follows:

After having decided that valve travel is equal on both sides of center of valve seat, the next problem is to set the valve in proper position relative to position of piston, and necessarily to the position of the crank. In case the eccentric cam has been keyed on the shaft and the valve travel has been equalized, nothing else can be done, since the only way to change the lead of the engine is to change the angle of advance or relative position of crank and eccentric cam. If engine were built correctly in the first place there is very little chance of this being out of place or wrong.

502 When cam is set-screwed to the shaft, place crank on back center, loosen up the set-screws, and turn eccentric ahead of crank (see Cut No. 2), until



Cut No. 2

it has moved the valve to a position which just opens the valve port, say 1-32 of an inch, which is ample for a small engine. When this has been done, fasten

eccentric cam to the shaft by set-screws and turn the crank over to the other center. See if the valve shows the same amount of opening that it did on the other end, which will be the case if the travel of the valve has been equalized correctly. Generally, however, imperfect core-work in casting the cylinder throws the position of the port out more or less, and the Engineer must use his judgment in setting valve and equalizing lead.

TO SET VALVE TEMPORARILY WITHOUT REMOVING VALVE CHEST COVER

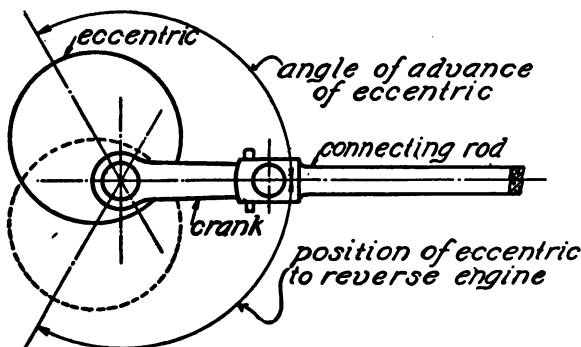
503 This is not a very correct method, but it is good enough for temporary application where time saving is a very important consideration.

504 If the eccentric cam is keyed to the shaft and the rods, links, etc., connecting cam to valve stem are all set right, the only probable difficulty is that the valve travel is unequal. In such a case, with most engines, the valve cannot be adjusted without removing cover to get at the valve nuts, and it will be more probable that the trouble is caused by some loose connecting part between cam and valve stem, such as loose key or bolt. However, if the eccentric cam is set-screwed to the shaft, the valve may be set readily in the following way, without taking off the valve chest cover :

505 First, loosen the eccentric cam set-screws; set crank on rear center, open front and rear drip cocks, open throttle valve so that there is a slight pressure of steam in the valve chest and cylinder, but not enough to move piston. With the crank and shaft stationary, rotate the cam until the valve is just open on the rear end, as will be made evident by the escape of steam through the rear drip-cock. Set up screws in cam. Turn crank around and see if steam escapes from the other drip as the crank is passing the other center. If so, the valve is set approximately.

TO REVERSE THE DIRECTION OF ENGINE

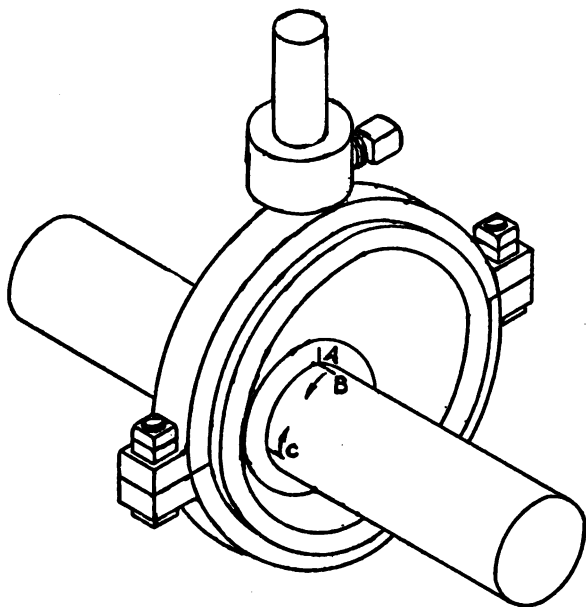
506 To reverse an engine, it is necessary to move the eccentric cam as much back of the crank as it was previously ahead. With the steam chest cover off, put crank on the rear center. Note the amount of lead, loosen up set-screws on eccentric cam and throw it over past the position of the crank until it is in the same relative position back of crank that it was previously ahead (see Cut No. 3), which will



Cut No. 3

be determined by the valve again coming to the position of lead previously noted. Set-up set-screws in the cam, and the valve is now in position to move the engine in the opposite direction. Verify the valve travel and lead on both ends in the usual way. This can be done approximately with the valve cover on by using the steam from the drip-cocks as indicator of the moment when the valve opens or has lead.

- 507 On many engines the eccentric cam is marked, and there is a corresponding mark on the shaft for each position of the eccentric cam. One mark at which the eccentric may be set to cause the engine to go one way, and another at which the eccentric may be set to cause the engine to go the other way. (See Cut No. 4.)



Cut No. 4

- 508 Never tighten the double nuts on the valve stem so that they bind the valve. The valve casting is designed to be loose, so that when pressure is put on it, it will seat itself on the planed surface over which it rides. (See Cut No. 1.)

509 For setting valves of double engines, like hoisting engines, adjust each side separately, without reference to the other, as though it were a single engine.

510 For setting valves of reversible link motion engines, the method is similar and just as simple. Throw the reverse lever into the go-ahead position; set the valve as previously noted; then throw the lever into the extreme reverse or backing position, and the valve travel should be correct without any additional change. If the engine be a double reversible, treat each engine as though it were an entirely independent machine. The principal trouble to be guarded against in setting or adjusting double or single reversible engines, is the loose motion of parts. The motion of the cam is transmitted to the valve stem through various levers, connecting rods and links, which, if worn and full of loose motion, will make it difficult to equalize the travel and adjust the lead.

FITTINGS AND SUPPLIES

- 511 For sheet packing use good plain inserted cloth rubber packing, and "Rainbow" packing where an extra quality is desired. Where two finished surfaces go together there is nothing better than thin sheet lead.

USEFUL DATA

- 512 The Horse Power of an engine is a variable quantity, depending on the size of the cylinder, length of stroke, boiler pressure, number of revolutions per minute, etc.
- 513 The following table shows in general the capacity of modern standard engines and may be useful to Superintendents for estimating the power of their engines:

Vertical Engines	Size of Cylinder	Revolutions per Minute
4 H. P.	4" x 5"	250
5 H. P.	5" x 5"	225
10 H. P.	7" x 7"	190
15 H. P.	8" x 8"	180
20 H. P.	9" x 9"	160
25 H. P.	10" x 10"	160
40 H. P.	12" x 12"	160
50 H. P.	14" x 14"	150

Hoisting Engines	Double Cylinder
10 H. P.	5½" x 8"
16 H. P.	6¼" x 10"
20 H. P.	7" x 10"
30 H. P.	8¼" x 10"
35 H. P.	8" x 12"
50 H. P.	10" x 12"

Horizontal Stationary Engines	Size of Cylinder	Revolutions per Minute
6 H. P.	4" x 6"	260
8 H. P.	5" x 8"	240
10 H. P.	6" x 9"	200
15 H. P.	8" x 10"	190
20 H. P.	9" x 12"	190
25 H. P.	10" x 12"	190
30 H. P.	11" x 15"	190
40 H. P.	12" x 16"	160
50 H. P.	14" x 16"	150
70 H. P.	16" x 24"	150
125 H. P.	18" x 27"	120
150 H. P.	20" x 28"	110

514 For making rough estimate on power of engine actually running, use this formula

$$\frac{2 \text{ PLAN}}{33,000} = \text{H. P.}$$

i. e., multiply twice the pressure of the steam in the cylinder (which averages about one half of boiler pressure), by the length of stroke reckoned in feet,

by the area of the piston in square inches, by the number of revolutions per minute. Divide this result by 33,000 and you obtain the Horse Power which the engine is developing under the conditions named. This formula would be nearly exact were it not for the fact that we cannot get exact average pressure in the cylinder without instruments especially designed, like the steam engine indicator, which are used for this purpose.

- 515 One horse power is equal to 33,000 ft. lbs. done in one minute, i. e., 33,000 lbs. lifted one foot per minute, or 33 lbs. lifted one thousand feet per minute, etc.

REMOVAL OF ENGINES

- 516 Never ship an engine with removable brass or small fittings in place, where they may be easily broken or stolen. Carefully pack them in the tool box.
- 517 The following table of weights of engines may be of use to Superintendents:

DOUBLE CYLINDER DERRICK ENGINES.

10 H. P.	5½" x 8"	weighs	6,100 lbs.
16 H. P.	6¼" x 10"	weighs	8,000 lbs.
20 H. P.	7" x 10"	weighs	8,400 lbs.
30 H. P.	8¼" x 10"	weighs	10,600 lbs.
35 H. P.	8" x 12"	weighs	16,400 lbs.
50 H. P.	10" x 12"	weighs	18,000 lbs.

FITTINGS TO BE SENT WITH BOILER

- 518 The following should be sent to jobs with all boilers:

An injector or inspirator with feed pipe, check valve and stop valve, gauge cocks, water column (if locomotive boiler), water gauge, gauge glass, safety valve, blow-off valve, complete set of grate bars, smoke stack, bonnet, water barrel, suction hose for inspirator, and boiler tools, such as a hoe, poker, slice bar and flue cleaner. For hoisting engines, see that parts include friction levers, brake levers, cylinder lubricators, oil cups, and cotton waste. An engine house and tool box should be sent with each engine.

CARE AND MANAGEMENT OF BOILERS

- 519 The first duty of the engineer when he comes on the job in the morning is to ascertain the water level in the boiler and not spread his fire or add fuel until he has done so. In this way he will save danger and, possibly, injury to the boiler.
- 520 It is the duty of the Superintendent to see that engineers keep a thin, clean fire in the furnace.
- 521 In case the boiler is found with low water at any time, immediately shut off all draught and cover the fire with ashes at once, or, if no ashes are handy, use fresh coal. Do not put water in the boiler or touch the feed in any way. Do not move or tamper with the safety valves or change the steam outlets, but let

the fire gradually cool down. In this way an explosion may be avoided and the boiler escape without serious injury.

FOAMING BOILERS

- 522 In case the boiler foams, close the steam outlets or throttle valves long enough to find where the water is in the glass, and the true level of the water in the boiler by also trying the gauge-cocks. If sufficient water is found in the boiler, proceed to alternately blow and feed until the water is freshened enough to cease foaming. If the level of the water is low and the foaming very violent, cover the fire and let the boiler cool down to about 10 pounds pressure by the gauge; then blow boiler entirely down and fill up with fresh water, after the boiler has become cool.

BLOWING DOWN BOILERS

- 523 No boiler can be entirely blown at a greater pressure than 10 lbs. on the gauge without danger of collapse or serious internal strain.
- 524 After having blown down a boiler, under no conditions fill the same with water until absolutely cool. Many a good boiler has been made leaky or spoiled (and the remote cause of a disastrous explosion laid) by lack of attention to this rule.
- 525 Superintendent will see that the engineer blows down his boiler a little at least twice per week, and blows it entirely down at the end of the job.

KEEPING BOILER IN GOOD CONDITION

- 526 Engineers are responsible for the condition of their engines and boilers. When not running or firing they are not expected to advise the Superintendent or consult the nearest foreman as to the conduct of the job, but are to occupy themselves with cleaning the bright parts of their machines, repairing oil cups, wiping, oiling, setting up glands, packing leaky joints, cleaning boiler flues, keying bolts, pins, etc. (especially in moving parts), to see that they are not loose, ascertaining that no part of machine has warmed unduly, examining boiler for leaky joints, staybolts, rivets, hand holes, pipes, etc., in short, attending to the endless details about the machine, which will amply fill an intelligent and money-making engineer's time.

DRY STEAM

- 527 See that your boiler gives dry steam, thus saving coal and water. A simple test of dry steam is made by opening the upper gauge cock. If the steam coming from the cock has a blue tinge and is practically transparent, it contains no more than one to two per cent of moisture; if it appears white it contains more moisture, and the steam is said to be excessively wet. Wet steam shows either that the boiler is overloaded and too small for the work assigned to it, or else the water is dirty, oily or impure from some other cause.

WASH BOILER

- 528 Keep exterior of boiler dry and interior free from scale and rust. Wash boiler out thoroughly as frequently as possible.

FUSIBLE PLUG

- 529 Examine fusible plug, if boiler has one, and keep its surface bright. This fusible plug should be placed at the highest fire line, but it is not entirely reliable, and should be examined frequently.

SAFETY VALVE

- 530 Engineers are instructed to try the safety valve on the boiler every day, without exception, and Superintendents will note any failure on their part to do so.
- 531 See that the blow-off point for the safety valve corresponds to the desired point on the steam gauge.

FEED VALVE

- 532 Engineers are responsible for having a stop valve placed in the feed pipe between the check valve and the boiler, so that in case of a leaky or defective check the boiler will not be endangered and the check may be repaired with steam on.

CLEAN FLUES

- 533 Superintendents will see that engineers clean the flues of their boilers twice per week if burning good coal, and daily if burning poor coal—in case of locomotive style of boilers.
- 534 In case of hoisting engines, where it is difficult to get at the tubes, they should be cleaned as frequently as possible.

BORROWING TOOLS

- 535 No workman shall take away the wrenches, spanners or tools belonging with the steam plant of the job, without the consent of the engineer, and then only on the authority of his foreman, who will be held responsible for their return to the engineer.

SPECIAL DUTIES OF ENGINEERS

- 536 Engineers are to be on the job early enough to have their machines ready for business when the work starts in the morning.
- 537 No engineer will be tolerated on the job who delays the work by injudicious firing, oiling, wiping, etc.
- 538 Engineers will maintain a proper water level in the boiler, of about two gauges of water. While too little water endanger the boiler, too much water is fatal to dry steaming.

GRATE BARS

- 539 Engineers will see that their grate bars are in good condition and report defective grates to the Superintendent. See that they are loose and have plenty of chance to expand without wedging. If they are too long, so that they wedge, or nearly wedge, when cool, they will expand, warp and twist when hot. Remedy such defects by chipping with cold chisel. Keep the air spaces in grate free from clinkers, as it requires air and plenty of it to burn coal economically.

GAUGE COCKS

- 540 Engineers will keep their gauge and water cocks clean and in good condition. Keep the wood disks of gauge cocks in good repair, and stems of cocks straight and in good condition. Keep gauge glass clean and protected at all times by the proper brass rods.

VERIFY WATER LEVEL

- 541 Engineers are hereby instructed to verify the water level of the boiler frequently by trial of gauge cocks, and to this end must see that they are kept in good condition.

ARCH DOOR

- 542 In case of locomotive boilers, engineers are to see that the door of the back connection or smoke arch fits closely and as near as possible to being air tight.

BLOW-OFF VALVE

- 543 Engineers are to see that blow-off valves are in good condition and do not leak. No leaky blow-off will be tolerated on any job for a single day, but must be repaired at once, temporarily, by putting a cast iron plug in the outer end. The leaky valve must be replaced by a new one at once.

BLISTERS

- 544 All blisters which appear on the boiler must be trimmed or patched at once.

LEAKS

- 545 In case the boiler shows signs of leak around stay-bolts, brace bolts, barrier bolts, or the like, the engineers should endeavor to caulk the same.
- 546 If boilers leak around hand holes, replace the gasket at the earliest possible moment.

- 547 If a leak appears in a seam, which a slight amount of caulking will not remedy, send for the nearest boiler maker to come and examine the boiler.
- 548 Have boiler maker give a hand hammer test for thin places and decide whether caulking, a soft patch, or a hard patch is required.
- 549 A soft patch is a piece of steel of sufficient size to cover leaky or thin area, bolted to the boiler with a joint of thick red and white lead paste. It is a temporary patch in every way, but will often remain good for a long time. By having the boiler repaired with a soft patch, the Superintendent can often avoid the expense of delay and make the boiler last out the job.
- 550 A hard patch is made by cutting away all the thin or leaky metal and riveting in an entirely new piece of metal. It is generally more desirable to mend a boiler by making a hard patch. This is not always possible, however, especially with small boilers, where it is impossible to get at the inside head of a rivet and hold it while the other end is being headed up.

LEAKY TUBES

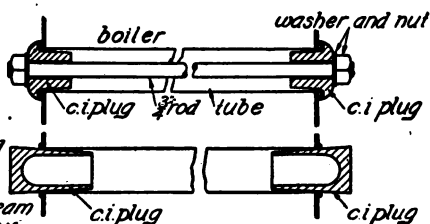
- 551 Roll leaky tubes when boiler is cold, with a Henderson Tube Expander. In giving size of expander wanted remember that size of boiler tube is measured on the outside, so that a $2\frac{1}{2}$ " tube will be $2\frac{1}{2}$ " outside, and about $2\frac{1}{4}$ " inside. In such a case, you would ask for a $2\frac{1}{2}$ " expander, i. e., to fit a $2\frac{1}{2}$ " tube.

PLUGGING TUBES

552 In case tubes should leak from being pitted or split, and it is not desired to lay up boiler, send at once to the office for one or more sets of cast iron tube plugs. State size and length of tubes and number you desire to plug. This is done with cast iron

*Rod Style
Best and most
satisfactory for
long jobs*

*Wedge Style.
Frequently used
as they can be
inserted while
boiler is under steam
and fire in firebox*



Cut No. 5

plugs of the proper size, one of which is inserted in each end of tube with proper lead joint, and they are held tightly in place by a long bolt running through the tube. (See Cut No. 5.)

PIPE.

553 In asking for pipe and fittings, remember that the sizes of pipe as named are merely nominal, and generally refer to the inside diameter of the pipe. This is especially uncertain in the case of small sizes. For instance $1\frac{1}{4}$ " steam pipe is $1\frac{3}{8}$ " inside diameter and about $1\frac{5}{8}$ " outside diameter. The same is more or less true with all sizes of pipe, and must be guarded against. The following table of standard sizes of wrought iron pipe for steam, gas or water, should always be referred to, in order to avoid mistakes.

554 In making up a pipe line, remember that a union must be placed in all pipe lines running from one fixed point to another fixed point. In general, order "Dart" unions, or some other malleable iron, soft-metal jointed union. Brass unions are too expensive for general use, and cheap iron ones are not good enough.

TABLE OF DIMENSIONS OF STANDARD WEIGHT OF WROUGHT-IRON PIPE

1½" AND SMALLER PROVED TO 300 LBS. PER SQUARE INCH BY HYDRAULIC PRESSURE
1½" AND LARGER PROVED TO 500 LBS. PER SQUARE INCH BY HYDRAULIC PRESSURE

Inside Diameter.	Actual Outside Diameter.	Thickness.	Actual Inside Diameter.	Inside Circumference.	Outside Circumference.	Length of Pipe Per Square Foot of Inside Surface.	Length of Pipe Per Square Foot of Outside Surface.	Inside Area.	Outside Area.	Length of Pipe Containing One Cubic Foot.	Weight Per Foot.	No. of Threads Per Inch of Screw Taper of Threads Per Inch of Screw
In.	Ins.	Ins.	Ins.	Ins.	Ins.	Ft.	Ft.	Ins.	Ins.	Ft.	Lbs.	In.
½	0.405	0.068	0.270	0.848	1.272	14.15	9.44	0.0572	0.129	2500.	0.243	27 ½
¾	0.54	0.088	0.364	1.144	1.696	10.50	7.075	0.1041	0.229	1385.	0.422	18 ½
1	0.675	0.091	0.494	1.552	2.121	7.67	5.657	0.1916	0.358	751.5	0.561	18 ½
1 ¼	0.84	0.109	0.623	1.937	2.652	6.13	4.502	0.3048	0.554	472.4	0.845	14 ½
1 ½	1.05	0.113	0.824	2.589	3.299	4.635	3.637	0.5333	0.866	270.	1.126	14 ½
1 ¾	1.315	0.134	1.048	3.292	4.134	3.679	2.903	0.8627	1.357	166.9	1.670	11 ½
2	1.66	0.140	1.380	4.335	5.215	2.768	2.301	1.496	2.164	96.25	2.258	11 ½
2 ¼	1.90	0.145	1.611	5.061	5.969	2.371	2.01	2.038	2.835	70.65	2.094	11 ½
2 ½	2.375	0.154	2.067	6.494	7.461	1.848	1.611	3.355	4.430	42.36	3.600	11 ½
2 ¾	2.875	0.204	2.468	7.754	9.032	1.547	1.328	4.783	6.491	30.11	5.773	8 ½
3	3.50	0.217	3.067	9.636	10.906	1.245	1.091	7.388	9.621	19.49	7.547	8 ½
3 ¼	4.00	0.226	3.548	11.146	12.566	1.077	0.955	9.887	12.566	14.56	9.055	8 ½
3 ½	4.50	0.237	4.026	12.648	14.137	0.949	0.849	12.730	15.904	11.31	10.66	8 ½
3 ¾	5.00	0.247	4.508	14.153	15.708	0.848	0.765	15.939	19.635	9.03	12.34	8 ½
4	5.563	0.259	5.045	15.849	17.475	0.757	0.629	19.990	24.299	7.20	14.50	8 ½
4 ¼	6.625	0.280	6.065	19.054	20.813	0.63	0.577	28.889	34.471	4.98	18.767	8 ½
4 ½	7.025	0.301	7.023	22.063	23.954	0.544	0.595	38.737	45.663	3.72	23.27	8 ½
4 ¾	8.625	0.322	7.982	25.076	27.096	0.478	0.444	50.039	58.426	2.88	28.177	8 ½
5	9.625	0.344	9.001	28.277	30.433	0.425	0.394	63.633	73.715	2.26	33.70	8 ½
5 ¼	10.75	0.366	10.019	31.475	33.772	0.381	0.355	78.838	90.762	1.80	40.06	8 ½
5 ½	12.00	0.375	11.25	35.343	37.699	0.340	0.318	98.942	130.097	1.455	45.95	8 ½
5 ¾	12.75	0.375	12.00	38.264	40.840	0.313	0.293	116.535	132.732	1.235	48.98	8 ½
6	14.00	0.375	13.25	41.268	43.982	0.290	0.273	134.582	153.938	1.069	53.92	8 ½
6 ¼	15.00	0.375	14.25	44.271	47.124	0.271	0.254	155.968	176.715	.923	57.89	8 ½
6 ½	16.00	0.375	15.25	47.274	50.265	0.254	0.238	177.867	201.062	.809	61.77	8 ½
6 ¾	17.00	0.375	16.25	51.05	53.40	.....	.....	.....	.....	.....	.....	.....
7	18.00	0.375	17.25	53.281	56.548	0.225	0.212	225.907	254.469	.638	69.66	.....
7 ¼	20.00	0.375	19.25	59.288	62.832	0.202	0.191	279.720	314.160	.515	77.57	.....
7 ½	21.00	0.375	20.25	63.61	65.97	.....	.....	.....	.....	.....	.....	.....
7 ¾	22.00	0.375	21.25	66.759	69.115	0.179	0.174	354.66	380.134	.408	85.47	.....
8	24.00	0.375	23.25	73.04	75.39	0.164	0.159	424.56	452.39	.339	99.37	.....

BOILER FITTINGS AND TOOLS

STEAM GAUGE

- 555 The steam gauge of a boiler should be plain, with no ornamentation of any kind, and but little advertisement on the face. It should be plainly and legibly numbered, and the hand should rest on the pin at zero when the boiler is cold.
- 556 Defective gauges must be repaired, reported, or replaced without delay. See that there is a siphon under each gauge. See that between each gauge and the boiler a stop-cock is provided so that the gauge may be removed or replaced while the steam is on.

WATER GAUGE

- 557 Every water gauge must be provided with a good shut-off cock at top and bottom, a valve at bottom by which glass may be drained, and two or more guard rods parallel to gauge glass to keep it from being broken.
- 558 No gauge glass smaller than $\frac{1}{2}$ " bore will be permitted on any boiler.

BLOW-OFF COCK

- 559 The blow-off cock should be provided with a good plug valve and not an ordinary gate or globe valve. The plug has the advantage of being simpler, less liable to leak, and the position of the handle tells at once whether it is open or closed.

TUBES

- 560 In ordering new boiler tubes, the Superintendent shall insist on charcoal *iron* lap welded boiler tubes made by the Allison Company, or guaranteed equal.
- 561 *No steel tubes* are to be allowed inside of any boiler, shop, yard or job controlled by this firm.
- 562 The Allison tube must be ordered from Philadelphia, Pa., or through the Agents at Providence, R. I., —Mr. E. M. Shaw, Bannigan Building.
- 563 The common iron boiler tubes on the market throughout New England are not to be depended upon, and the *very best tubes are none too good*.

COAL

- 564 In calculating the amount of coal needed for a boiler, use the following:
- The average boiler burns 12 lbs. of soft coal per hour per square foot grate surface. Figure up the square feet of grate surface and multiply by 12, and you have the number of pounds of coal you need per hour.

WATER

565 For calculating the water required for the boiler, roughly:

 Multiply the H. P. of your boiler by 30, which gives the pounds of water per hour; then divide by 8, which gives approximately the number of gallons per hour. (i. e., Am. Society Mechanical Engineers rule is that one boiler H. P. equals 30 lbs. of water evaporated at 70 lbs. gauge, per hour; feed water at 100 degrees F.)

PUMPS

COST OF PUMPING.

566 Triplex, belted, or geared pumps require from two to four lbs. coal per H. P. hour; Small steam pumps, twenty-five lbs. per H. P. hour; Inspirators or Ejectors about 100 lbs. per H. P. hour; Centrifugal direct connected or belted pumps from five to ten lbs. per H. P. hour.

TO SET UP A CENTRIFUGAL PUMP, WHETHER DIRECT CONNECTED TO ENGINE OR NOT.

567 See that it has a firm bed so that it will not shake to pieces. If belt is used with pump, attach power in such a way that pump will rotate or run in the direction of the scroll. Put the suction in place in a thorough manner and see that there are no air leaks in the pipes or joints. On the end of suction, place a combined strainer and foot valve, the latter to enable the engineer to prime the pump by inserting hose in the discharge. Use discharge pipe full size bore of

pump, and suction pipe at least one size larger. See that the stuffing boxes on either end of shaft are well packed and well oiled. Remember that no pump will lift water much over thirty feet, and a centrifugal pump scarcely over twenty-eight feet, although any pump with plenty of power behind it will force water very much further. Imperfect connections cause trouble and prevent starting pumps. See that the suction pipe is large, air-tight, and with few bends and elbows.

- 568 In cold weather drain the pump out to prevent freezing, when it is not in use.
- 569 For the convenience of Superintendents, the following tables show the speed required and the power necessary for centrifugal pumps.

CENTRIFUGAL PUMPS

No. Pump (Diameter, Discharge, Opening)	Size Pipe Flange on Suction, Inches	Economical Capacity, in Gallons, per Minute	Horse Power Required for each Foot Elevation	Diameter and Face of Pulley, in Inches	Floor Space Required in Inches, Without Primer	Shipping Weight without Primer, Lbs.	Shipping weight with Primer, Lbs.	Price without Primer, per Fig. 16	Price with Primer, per Fig. 17	Price Extra if Brass Fitted	No. Pump
1 1/4	2	70	.058	6 x 6	17 x 31	175	220	\$ 45	\$ 55	\$ 12	1 1/4
1 1/2	2	90	.075	7 x 8	21 x 32	260	305	60	70	15	1 1/2
2	3	120	.10	8 x 8	23 x 37	350	415	75	90	18	2
2 1/4	3	180	.15	8 x 8	24 x 38	360	430	90	105	22	2 1/4
3	4	260	.22	8 x 8	25 x 39	415	495	110	130	25	3
4	5	470	.30	10 x 10	29 x 41	615	720	130	155	40	4
5	6	735	.45	12 x 12	34 x 54	940	1075	165	185	60	5
6	8	1050	.59	15 x 12	37 x 55	1180	1345	200	240	90	6
8	10	2000	1.00	20 x 12	45 x 64	2065	2430	310	375	130	8
10	12	3000	1.52	24 x 12	51 x 69	2610	2940	395	470	165	10
12	15	4200	2.00	30 x 14	63 x 71	3615	...	500	...	275	12
15	18	7000	3.50	40 x 15	77 x 80	7100	...	850	...	...	15
15*	18	7000	3.50	30 x 15	60 x 68	3150	...	710	...	...	15*
18	20	10000	4.50	40 x 16	94 x 103	9000	...	1300	...	...	18
18*	20	10000	4.50	30 x 16	66 x 72	4835	...	1150	...	...	18*
20	22	12000	5.40	36 x 20	73 x 83	6800	...	1600	...	...	20
22	24	13000	5.50	48 x 20	126 x 130	...	...	...	...	...	22
24	24	15000	6.50	48 x 36	94 x 137	...	...	...	...	...	24

REVOLUTION TABLE

No.	5 Feet	10 Feet	15 Feet	20 Feet	25 Feet	30 Feet	35 Feet	40 Feet	50 Feet	60 Feet	70 Feet	80 Feet	90 Feet	100 Feet	No.
1½	428	604	739	854	955	1045	1131	1208	1351	1481	1599	1714	1818	1911	1½
1¾	348	491	601	695	777	850	920	982	1099	1205	1301	1394	1475	1554	1¾
2	302	426	522	603	674	737	798	852	953	1045	1128	1210	1280	1348	2
2½	302	426	522	603	674	737	798	852	953	1045	1128	1210	1280	1348	2½
3	302	426	522	603	674	737	798	852	953	1045	1128	1210	1280	1348	3
4	285	402	493	569	637	697	754	805	901	987	1066	1143	1209	1274	4
5	256	362	443	512	572	626	678	724	810	887	958	1027	1087	1145	5
6	214	302	368	427	478	523	566	604	675	740	800	857	907	955	6
8	183	259	317	366	409	448	485	517	579	634	685	735	777	819	8
10	168	238	291	336	376	411	445	475	532	582	629	675	714	752	10
12	133	188	230	266	298	326	352	376	421	461	498	534	565	595	12
15	105	148	181	209	234	256	277	295	331	362	391	420	444	468	15
15*	151	213	261	301	337	369	399	426	477	522	564	605	640	674	15*
18	105	148	181	209	234	256	277	295	331	362	391	420	444	468	18
18*	151	213	261	301	337	369	399	426	477	522	564	605	640	674	18*
20	142	202	245	285	317	348	376	403	450	492	532	570	602	635	20
24	95	134	163	190	212	233	252	268	300	328	355	378	403	424	24

STEAM CENTRIFUGAL PUMP

Size of Pipes.		Size Engine Cylinder		Rated Capacity of Pump. Gallons Per Minute.	Greatest Height for which Recommended. Feet.	Total Weight. Pounds.
Suction, Inches.	Discharge, Inches.	Diameter Inches.	Stroke Inches.			
3½	3	4	4	250	12	900
4½	4	4	4	450	18	1050
6	5	6	6	700	20	1750
6	6	6	6	1200	25	1950
8	8	7	7	2000	25	3400
10	10	8	8	3000	20	5600

NOTES ON PUMPS

- 570 In general, it may be said that centrifugal pumps are by far the most advantageous for the contracting business. They contain no valves, are not easily clogged by sand or dirt, and they are very economically run as far as coal is concerned. However, it may be necessary for a Superintendent to set some form of a Reciprocating Steam Pump. The following notes will be of use:
- 571 It is better, on general principles, to use the Duplex Pump, as it is by far the simplest.

DIRTY VALVES

- 572 The most frequent trouble in the ordinary steam pump comes from dirt in the water valves. In case the pump will not draw, remove water end cover and middle plate, and examine rubber valves. If dirty, clean the sand and grit from the seats, see that the rubber valves are soft and pliable, and that the springs are not broken and are in running order.

AIR CHAMBERS

573 Where there is a long, hard lift, it is very useful to put on what is called an "Air Chamber" on the suctions. This is usually a vertical piece of pipe, three or four feet long, closed on the top, erected from the suction pipe near the pump. This air chamber tends to collect the air from the water in the suction and prevents the suction from breaking or air collecting in the cylinder and cushioning between the piston and head.

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